

SCRUB TYPHUS AND SCRUB ITCH

in the

UNITED STATES ARMY IN WORLD WAR II

by

Colonel Cornelius B. Philip, SnC*
1 October 1946

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I. INTRODUCTION AND TOTAL INCIDENCE

"Scrub Typhus Fever is a serious disease prevalent in the Asiatic-Pacific Area. In some operations it disabled more men than did enemy action. Because of expanding military activity in this area, all individuals should know how to protect themselves from it." Thus reads the opening statement of an Army Ground Forces Headquarters' directive in late 1944 to various units of troops staging in the United States as part of the preparation for the final assault on Japan.¹

Fortunately, the early capitulation of Japan obviated the need for completion of anti-mite preparations and for issuance of supplies of improved repellent plus indoctrination of troops already under way based on lessons gleaned from experience with scrub typhus or tsutsugamushi disease in previous campaigns. That experience will be discussed hereafter as three major episodes, two in the Southwest and South Pacific (S.W.P.A.) and the other in the China-Burma-India (C.B.I.) Theaters of Operation (Chart I).

The noncombat occupation in the fall of 1945 by units of the Sixth Army (11th Airborne and 27th Divisions) of the three notorious, endemic prefectures, Akita, Yamagata and Niigata in Northwest Honshu minimized any need for field exposure in the local areas. This, coupled with the lateness of the season, resulted in the lack of any cases in military personnel during the 1945 administrative operation in Japan.² Though there was some apprehension regarding the disease preparatory to the earlier Okinawa invasion, no cases of scrub typhus

Chart I. The areas in which occurred the three major episodes of scrub typhus in American Army Forces; numbered in reference to discussion in Sections II, III and IV in this History. These are shown in relation to known distribution of the disease in the Asiatic-Pacific Region (adapted from Blake et al, 1945).¹¹

were encountered during those operations.³

For intelligent subsequent presentation of epidemiological features of the disease in the Army experience it is necessary to provide statistics on the incidence of scrub typhus in the various theaters.

The total number of cases of scrub typhus in American Army Forces in all areas from March 1942 through December 1945 was 6,717 as reported by the STATISTICAL HEALTH REPORTS in The Surgeon General's Office.

Table I gives a breakdown of cases by theaters and areas, i.e., SWPA-5,718, SPA-32, and CBI-967.* The 5,718 SWPA cases included 301 in troops during re-occupation of the Philippines from November 1944 through December 1945; and 28 in Australia in those two complete years. Separate data are not available for the latter country for 1942 and 1943. It is likely that two known cases of murine typhus in the Philippines and a few in Australia are included in the totals due to the methods of reporting all types of typhus as a combined figure in military statistics. Similarly in the total of 967 cases for the CBI, separate reporting of "e" (epidemic or endemic [murine] typhus) from "s" (scrub) typhus was not initiated until March of 1945. The figures have not been corrected to eliminate 24 such known cases of endemic typhus which were included in the Statistical Health Reports subsequent to that date, for consistency with other historical data. Of

* Some dozen cases have been reported from the U.S. at various times during the war for various reasons. In at least one instance, a case developed infection en route to the U.S. by plane and was first reported from a hospital in August 1945, Camp Kilmer, N.J. Another case, reported as "an aviator", was hospitalized in San Francisco 7 days after arrival with clinical symptoms and positive OXK serology after exposure in a South Pacific Island.⁹⁴ Such reports were corrected as to locality as soon as the reports were received by the Medical Statistics Branch of the SGO.⁹¹

the 967 CBI cases, 112 were reported from China, many of which were probably endemic typhus.³³ It is not known how many were actually scrub typhus, or came over from Burma during their incubation periods, as discussed later.

The figures of 1000/year rates given in Table II show totals for the four years 1942-1945 of 3.34 and 2.23 for the SWPA and CBI, respectively. The highest rate of 9.75 for SWPA other than Australia and the Philippines in 1944 is due chiefly to two major epidemics encountered on the Owi-Biak and Sansapor beachheads in New Guinea, also discussed below. A comparison of monthly attack rates in the two areas is shown in Chart V.

The figures in both Tables I and II provide columns for South Pacific Area (SPA) to include a few cases* which occurred in the Army Forces on the Islands of Espiritu Santo, New Georgia and Bougainville before the last was transferred from the jurisdiction of the South Pacific to Southwest Pacific Theaters in August 1944.^{5,6,7} Although indeterminate reference has been made to a focus of the disease on one of the Treasury group of islands, South of Bougainville, which was occupied chiefly by Naval personnel, other reports indicate only the occurrence of severe, mite-caused, scrub itch. Almost 80 per cent of the sick bay calls there were due to lesions initiated by these mite-bites.⁸ Only 3 cases of scrub typhus were reported from Espiritu Santo. They were members of an Engineering

* Because it had been suggested that a large proportion of the 176 total (1942-1945) typhus cases in the Central Pacific Area (incl. SPA) forces were probably scrub typhus, attention is called to the report of 106 cases of murine typhus in the Hawaiian Islands for 1943-1944,⁹² and more probably occurred in 1945. On the other hand, while 32 cases of scrub typhus are reported officially for SPA by the Statistical Health Reports, Table I, 65 and "over 70" cases are specifically mentioned in individual reports^{70,93} for the island of Bougainville alone in SPA.

TABLE I
CASE INCIDENCE OF SCRUB TYPHUS FEVER
IN THE UNITED STATES ARMY

1942 — 1945

Source: Statistical Health Reports

1942	RNPA				SPA		CBI	
	Total	Aust.	Phil.	Other	Total	Burma India	China	
Mar	1							
Jul	1	1						
Aug	2							
Sept	8							
Oct	7							
Nov	7							
Dec	8							
TOTAL	34	1						
1943								
Jan	92					1		
Feb	62							
Mar	45							
Apr	55							
May	64							
Jun	79							
Jul	83							
Aug	81				1	1		
Sept	95					8		
Oct	93					2		
Nov	67					4		
Dec	119				5	40		
TOTAL	935				6	56		

TABLE I. (Continued)

1944	S S P A			E P A		C B I	
	Total	Aust.	Phil.	Other	Total	Burma India	China
Jan	75	1		74	2	10	
Feb	104	6		98	3	21	
Mar	184	2		182	3	2	
Apr	75	1		74	5	37	
May	130			130	8	67	
Jun	212	11		201	3	64	
Jul	647	2		645	2	45	
Aug	1759			1759		38	
Sept	757	2		755		45	
Oct	251	1		250		103	
Nov	113		1	112		89	81 8
Dec	89		12	77		89	84 5
TOTAL	4396	26	13	4357	26	610	165 13
<u>1945</u>							
Jan	100	2	86	12	108	102	6
Feb	66		49	17	33	27	6
Mar	45		23	22	26	6	20
Apr	32		27	5	14	1	13
May	15		13	2	10	1	9
Jun	43		40	3	31	10	21
Jul	20		18	2	28	16	12
Aug	11		10	1	19	8	11
Sept	3	*	2	*	14	8	6
Oct	11	*	*	*	11	8	3

TABLE I. (Continued)

1945	SWPA				Total	CBI	
	Total	Aust.	Phil.	Other		Burma India	China
Nov	2	*	1	*	5	2	3
Dec	5	*	2	*	2	0	2
TOTAL	353	2	271	64	301	189	112

1942—1945

GRAND TOTAL	5718	(31)	(301)	(4421)	32	967#	(354)	(125)
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Grand total all 3 theaters

6717

*Unreported though troops in area.

#Not corrected to exclude 24 known cases of endemic (murine) typhus, reported between March and November 1945, from China and Burma to the Medical Statistics Division, SGO.

TABLE XI

ADMISSION RATES PER 1,000 PER YEAR, BY MONTHS

Source: Statistical Health Reports

1942	S N P A			S P A		C E I	
	Total	Aust. Phil.	Other	Total		Burma India	China
Mar	.96						
Jul	.12						
Aug	.27						
Sept	1.06						
Oct	.71						
Nov	.87						
Dec	.96						
Total	.51						
<u>1943</u>							
Jan	8.89				.56		
Feb	6.99						
Mar	4.55						
Apr	4.12						
May	5.62						
Jun	6.26						
Jul	4.55						
Aug	5.12			.09	.30		
Sept	4.08				1.94		
Oct	4.64				.28		
Nov	3.06				.66		
Dec	4.04			.33	4.41		
Total	4.79			.04	1.22		

TABLE II. (Continued)

1944	S W P A				S P A		C B I	
	Total	Aust.	Phil.	Other	Total	Burma India	China	
Jan	3.13	.12		4.66	.12	1.33		
Feb	4.26	.85		5.65	.17	2.59		
Mar	5.19	.24		6.68	.15	.17		
Apr	2.28	.17		2.72	.28	3.60		
May	3.70			4.36	.46	5.62		
Jun	4.12	1.72		4.46	.16	4.10		
Jul	13.40	.42		14.84	.20	3.46		
Aug	34.56			37.59		2.80		
Sept	11.70	.43		12.58		2.53		
Oct	4.60	.29		4.88		7.12		
Nov	1.92		.06	2.82		5.77	5.98 4.26	
Dec	1.21		.43	1.78		4.44	4.79 1.99	
Total	7.93	.41		9.75		3.82		
1945								
Jan	1.66	1.01	2.67	.46		6.17	6.71 2.60	
Feb	1.10		1.36	.76		1.77	1.69 2.24	
Mar	.62		.49	.94		1.08	.29 5.60	
Apr	.54		.63	.33		.74	.06 4.26	
May	.25		.28	.15		.55	.07 2.60	
Jun	.56		.64	.22		1.31	.54 4.13	

TABLE II. (Continued) (latter half of 1945)

1945	S W P A				S P A		C B I	
	Total	Aust.	Phil.	Other	Total	Burma India	China	
Jul	.31		.32	.29	1.49	1.13	2.63	
Aug	.11		.13	.01	.82	.47	1.78	
Sept	.04	*	.04	*	.75	.59	1.19	
Oct	.12	*	*	*	.65	.60	.84	
Nov	.02	*	.02	*	.30	.14	1.12	
Dec	.08	*	.01	*	.27		1.92	
Total	.35	*	.48	*	1.35	1.96	.26	
<u>1942--1945</u>								
<u>GRAND</u>								
<u>TOTAL 3.24</u>					<u>2.23</u>			

*Unreported though troops in area.

Construction Battalion engaged in clearing brush during the 19 to 24 days prior to their onsets. Characteristic symptoms were observed and all developed positive OXK agglutinins as checked in two laboratories. This constituted the farthest Eastern locality in which scrub typhus was encountered. No other reports of the disease were forthcoming from any of the islands in the Central or South Pacific Theater.^{4,11}

II SCRUB TYPHUS IN NEW GUINEA AND ADJACENT AREAS

The Essential Technical Medical Data report from Southwest Pacific Area for 5 October 1944 summarized the experience with scrub typhus up to that time as follows:⁹

"The first cases of scrub typhus in this theater were noticed late in 1942 as troops began to move into New Guinea. During the last five months of that year, the total of 32 cases were reported, but in January 1943 the number rose to 92 for a single month. Thereafter, the rate remains about the same with a total of 925 cases being reported in 1943, and 438 cases in the first six months of 1944. At that time, task forces moving into Dutch New Guinea were struck with the disease in epidemic form and twice as many cases occurred in the ensuing ten weeks as had occurred in the previous twenty-three months, a total of 2,843 cases so reported."

Up to that time minor foci were encountered in northern Queensland, Australia, and at Port Moresby and Milne Bay in New Guinea, while more important outbreaks occurred in the Oro Bay-Dobadura, Markham Valley, Goodenough Island areas as well as Cape Gloucester in New Britain.¹⁰ "The disease was continuously encountered as the military operations moved northward along the Coast to Salamauna, Wau, Lae, Nadzab and Finschhafen¹¹ during this earlier period, but these episodes all remained of relatively minor epidemiological significance.

"The mortality rate (in report dated 1 February 1944¹²) is not significant in a military sense. However, in the mortality rate from all diseases in the theater, typhus deaths account for 30 to 50%. The mean case fatality rate remains low...."

In comparison with the over-all incidence and rate in ONPA given in Table I and II, a summary of the incidence, mortality rate and case fatality rate is shown in Table III for the period, August 1942 to December 1943, based on strength only of troops in bases north of Australia.¹⁰ These figures are consequently higher but give a better picture of noneffective rates due to scrub typhus in foci encountered in forward areas of operation.

The experiences of individual units were sometimes more serious.

"In one unit, with a strength of 1,565, that had an average exposure period of 11.74 days in the Markham Valley, 37 cases of scrub typhus developed.... The admission rate for the period exposed was 73.5 per 1000 per annum and the average length of stay in the hospital was in excess of 70 days. Thirty-three were evacuated to the mainland in which one death occurred (the Commanding Officer of Company F)."¹⁰

The two most serious episodes in the entire Army experience in any area followed almost immediately the landings on Owi-Biak and Sansapor beachheads in Dutch New Guinea between June and August 1944.

"These two outbreaks provided about 2,000 cases.# Although mortality was very low (about 2 per cent) the loss of time from duty represents a major military handicap.... Many cases of over 20 febrile days duration and about 5 per cent seriously ill cases were seen."¹⁰

Earlier in the year a flight surgeon had called attention to the lighter incidence among Air Forces:

"Certain correlation has become evident between the military functions of troops and their physical conditions. Incidence of scrub typhus (tsutsugamushi fever) has been almost negligible among Air Force troops whereas the incidence is considerable among Ground Forces of both the American and Australian Forces."¹³

"Medical data on this disease are presented in other reports but a minimum of such data are also included in this section to emphasize such epidemiological features as differences in virulence in different outbreaks, and the potential military cost in time lost to provide a basis, if desired, for contrast with other infections such as dengue.^{18,44}

Actually over 2,500 in the two areas by the end of 1944.^{36,41}

TABLE III

SCRUB TYPHUS IN BASES NORTH OF AUSTRALIA

DURING 1942 AND 1943[#]

Period	Cases	Deaths	Incidence Rate	Mortality Rate	Case Fatality Rate	Strength
			per 1000 per annum	per 1000 per annum		
<u>1942</u>						
August	2	-	5.02	-	-	5174
September	8	-	10.40	-	-	9933
October	7	-	3.55	-	-	20474
November	7	-	3.08	-	-	29457
December	8	2	2.96	.74	2.5	35044
<u>1943</u>						
January	92	4*	22.80	1.0	4.3	41954
February	62	1	25.73	0.41	1.6	31315
March	45	5*	12.91	1.43	11.1	45291
April	43	2	10.52	0.48	4.6	53125
May	76	-	-	-	-	57624
June	79	5*	18.65	1.18	6.3	55049
July	83	6*	10.73	0.78	7.2	80375
August	81	3*	11.47	0.42	3.7	91772
September	85	5*	9.53	0.56	5.8	115864
October	93	4	7.79	0.33	4.3	124159
November	67	3	5.58	0.25	4.5	156158
December	119	13	6.74	0.74	10.9	183549
<hr/>						
TOTAL for period 957	53		9.42	0.55	5.90	66842

[#]Source: Essential Technical Medical Data, GMPA, 5 October 1944
(error in Nov 1943 figures corrected)

*Typhus-malaria deaths

However, after establishment of Sixth Air Force Headquarters and supporting units on Owi Island, there was a sharp increase in incidence in the AAF personnel epidemic. By 10 August, when the epidemic was well under way and the strengths of the Air and Ground Forces were approximately equal on the Base there were 288 cases in the Air Force and 259 cases in the Ground Forces on Owi Island plus an additional 205 in the Ground Forces on Biak.¹⁴ An account of the epidemic in the Air Forces in Owi-Biak states¹⁵

"During the week ending 5 August, the epidemic had spread until there was a weekly rate of 750 cases per 1000 per year. During the week ending 26 August the weekly rate dropped to 114 cases per 1000 per one year. From August 26 to 11 October there was an average of 2.3 per day dwindling to three cases in the last eight days of the period. The latter was the result of negligence in abiding by existing regulations on the prevention of scrub typhus. There has been a total of 716 cases with three deaths out of an average strength of approximately 15,000..... The febrile periods usually lasted about two weeks; of milder cases 58 were returned directly to duty; of this number 18, or 30%, had to be re-hospitalized because of severe asthenia and symptomatic tachycardia."

At the time of a visit in December of the same year there were in two general hospitals on Biak 32 such readmissions, diagnosis asthenia and neurasthenia, four of which were readmitted for the third time including their initial attacks of scrub typhus in August. The total number of primary cases by this time had reached 1,469 for the two Islands, with 7 deaths and a possible eighth in an evacuee, giving the remarkably low total mortality rate of 0.06 per cent.¹⁶ On the basis of a conservative estimate of an average loss of 60 to 70 man-days per primary patient,^{13, 20} the epidemic on the Biak base represented a potential loss to the Army of 900,000 man-days, or including the Sansapor epidemic, 1,50,000 man-days potentially chargeable to these two disasters.¹⁸

Epidemiologically, therefore, such low mortality rates and variations in virulence are deceptive in evaluating the military cost chargeable to scrub typhus.

The cost on the military sense is even more strikingly illustrated by experience in the Sansapor epidemic. Within the first twenty days of landing there were 403 hospitalizations in the 1st Infantry Regiment alone. Among these were the regimental commander, executive officer and 10 other staff officers, 5 company commanders, and 13 other officers.¹⁷ Quoting from another account:¹⁸

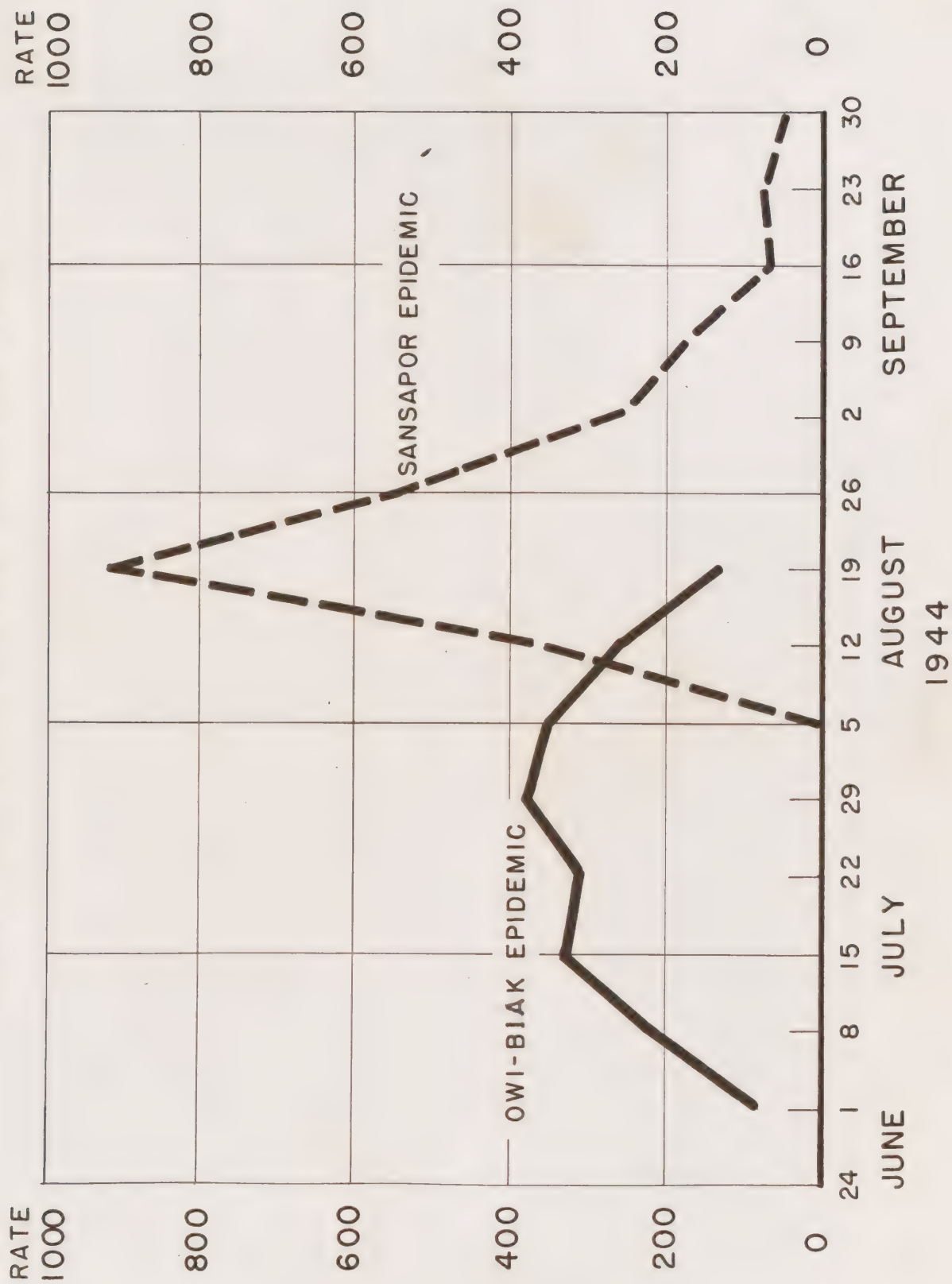
In contrast to 'E' (Sansapor), where there were 135 cases with onsets by D+13, only four of the cases from the earliest units arriving at 'D' (Owi Island) had onsets by that equivalent time after arrival, and the epidemic built up much more slowly at 'D'. It is not known what percentage of infection in the respective local mite populations was but study of the case distribution suggested that the relatively longer incubation periods at 'D' were in part also a reflection of the lower level of virulence."

In fifty-three days during the epidemic at Sansapor there was a total of 931 cases hospitalized, with a mortality rate of 3.4 percent,¹⁸ and the extraordinary number of nine primary eschars on one patient, and others not infrequently with multiple eschars indicated that the local mite population must have carried a high rate of infection. Data on admission rates on 1000/year basis for the combat periods during the Sansapor and Owi-Biak epidemics are given in Chart II. In view of the strain on hospital facilities and the severity of this infection, the noneffective curve for the Sansapor epidemic is indeed a prodigious one. The peak, which was as an individual episode higher than any yearly rate for all causes in the entire American Army, was reached within three weeks of D-day (July 31st) and could have been serious if there had been intense enemy opposition.¹⁸

Chart II. Hospital admission rates (1000/year basis) for the two largest outbreaks of scrub typhus both of which occurred in Dutch New Guinea, during combat periods at each beachhead. The Sansapor curve reached a higher peak by the third week than any total annual hospitalization rate in the Army for all causes in all theaters during World War II.

SCRUB TYPHUS

WEEKLY ADMISSION RATES 1000 PER YEAR



In beachhead or airborne types of combat operations, it was often possible to determine rather exact incubation periods in initial cases thus aiding local epidemiological observations and determination of foci. The shortest noticed in Army personnel was a case hospitalized on D + 6 in the Sansapor episode,^{18*} and contracted during bivouac at the mouth of the Newe River (Mar Village). Usually cases began to appear in exposed units within one to two weeks of initial exposure in focal areas as in the 864th Aviation Engineers and other early units on Owi Island. (Table V, p. 43).

On the other hand, at least three episodes occurred in which there was a peculiar delay in appearance of cases for some weeks after units were installed.¹⁹

"The first was in personnel of the 17th Station Hospital at Milne Bay, which moved into and cleared its area in early September; nine cases developed the third and fourth months (November 15 to January 15) long after the presumed maximum exposure had occurred without accountable change in local activity."

In the second instance of delayed case occurrence, approximately two hundred men were engaged in clearing hospital areas for the adjoining 360th Station and 9th General Hospitals on Goodenough Island during September and October, 1943.¹² Both hospitals then moved in late in October, resulting in a total exposure of some 1,000 persons. Cases of scrub typhus then appeared in November and December among personnel of the 9th General Hospital, total 24. In the patients and personnel of the 360th Station Hospital, the bulk of an additional 24 cases occurred in the last half of December, long after maximum exposure would have been expected to occur.

*One report by J.B. Logue in October 1944, U.S. Naval Medical Bulletin (43:645-649) cites one instance of onset 4 days after initial landing.

In the third episode,^{19,20} seventeen cases developed near Finschhaven in four batteries of an Air Warning Battalion situated in an unusually well cleared area (See Fig. 1) previously occupied by another battalion which had moved out six weeks previously after approximately three months' residence without occurrence of any cases. Other unaffected units were in close proximity on all sides. The battery of the subsequent occupants with the most cases had been installed 88 to 112 days before onsets of their cases. Investigation suggested these seventeen plus the only two that occurred in any adjoining unit were contracted during clearing and early attendance of a newly completed grassy amphitheater in an adjacent ravine (Fig. 2). Ironically, the theater was dedicated to the first victim before it was known that he had probably contracted his infection during initial work on this project. (The "T.J. Ayres Theater").

The last two of these small episodes also involved the highest mortality of any individual outbreaks in Army experience, viz., 27.5 per cent (Goodenough) and 35.3 per cent (Finschhaven) respectively.

On invitation of the Chief Surgeon, SWPA, a field team was sent by The Surgeon General through the Board for Investigation and Control of Epidemic Diseases and the Director of the United States of America Typhus Commission (hereinafter referred to as USATC) to New Guinea to study the epidemiology, clinical features, and etiology of scrub typhus in the troops. The original five members of this team set up a laboratory headquarters (Fig. 5) at the 3rd Medical Laboratory, Dobadura, on 19 October 1943.¹¹ As the disease was increasingly encountered in 1944, one to three new members of this team continued field and laboratory investigations as well as assisting on invitation in control work and the indoctrination of troops in anti-mite practices



Figure 1. Looking down from a grassy slope on the company area occupied by Company C, 478th Antiaircraft Artillery Air Warning Battalion, Finschhafen, British New Guinea, in which a small epidemic of unusual severity occurred. The living areas were exceptionally clean and bare. (USATC Neg., CBP)



Figure 2. Cases in the 478th Antiaircraft Artillery Air Warning Battalion were traced to the clearing and attendance of the theater area shown here. (USATC Neg., CBP)

discussed later. A part of this group then continued with the troops during re-occupation of the Philippines.²⁶ The history of the activities of this team is being presented in another report by the Director of the USATC. All of the original members of the team and subsequent replacements received the United States of America Typhus Commission medal.

III SCRUB TYPHUS IN THE PHILIPPINE ISLANDS

The disease was of only incidental military importance during the operations in the Philippines compared to the larger New Guinea and Burma episodes. The political importance, however, of finding the first incontrovertible evidence of wide spread foci on six islands in the Archipelago during military re-occupation in the present war justifies discussion of this experience as a separate major episode in this history of scrub typhus.²⁶

Incidence and rates in American Forces, from the Army Statistical Health Reports are separately tabulated for the Philippines in Table I and II, with a total of 301 reported cases (there were in addition hospitalizations of Naval personnel on two of the islands^{23, 24}).

The Islands remained a part of the SWPA Theater, though the military authorities in the Archipelago were changed in titles respectively from USAFFE and USABOS to Army Forces in the Pacific (AFPAC) 3 April 1945, and Army Forces in the Western Pacific (AFWESPAC) 7 June 1945.

The first cases in the Army developed in late 1944 during the Leyte Campaign, but this island remained a very minor focus. These were soon followed by the two largest though still moderate outbreaks in Armed Forces on Samar and Mindoro,^{23,24,26} each of which built up within five months to just under 100 military casualties; but only a

third of those on Samar were Army cases. Other islands on which small numbers of Army cases originated, mostly during combat operations, were Luzon, Negros and Mindanao. Those on Luzon were widely scattered and not more than six occurred in one locality. In spite of report of cases in Japanese troops in unspecified areas of Mindanao,²⁵ only one proved case was contracted in American Army Forces.²⁶

In a total of 222 American cases, the occurrence of only ten deaths or a mortality rate of 4.5 per cent revealed no foci of high virulence;²⁶ data on the remainder of the 301 total cases (Table I) are not yet available. Distribution of foci where one or more cases were contracted in the Philippines is shown in Chart III.

IV THE CHINA-BURMA-INDIA EPISODE

The third of the major Army episodes with scrub typhus occurred chiefly along the Stilwell (Lede) Road in northern Burma during staging and combat operations. The close integration of Chinese troops in these operations emphasized the desirability of reporting their parallel²⁷ experience with the disease.

While the infection again was found to have localized or "place" occurrence in a given area, it was nevertheless widely distributed in northern Burma. It was encountered in spots along the entire length of the Road at various times in the operational period of November 1943 through July 1945, as well as at points in the Lede area of north-western Assam, in the Fort Hertz district, and in some other outlying areas near Lashio and along the Burma railroad (Chart IV). During this period there were 5 distinct peaks in case occurrence, the first and last concerning chiefly the Chinese, with minor increases in American

Chart III. Location of known foci of scrub-typhus encountered by troops on six of the Philippine Islands during American re-occupation in 1944-45 (adapted from Philip, Woodward and Sullivan, 1946)²⁶

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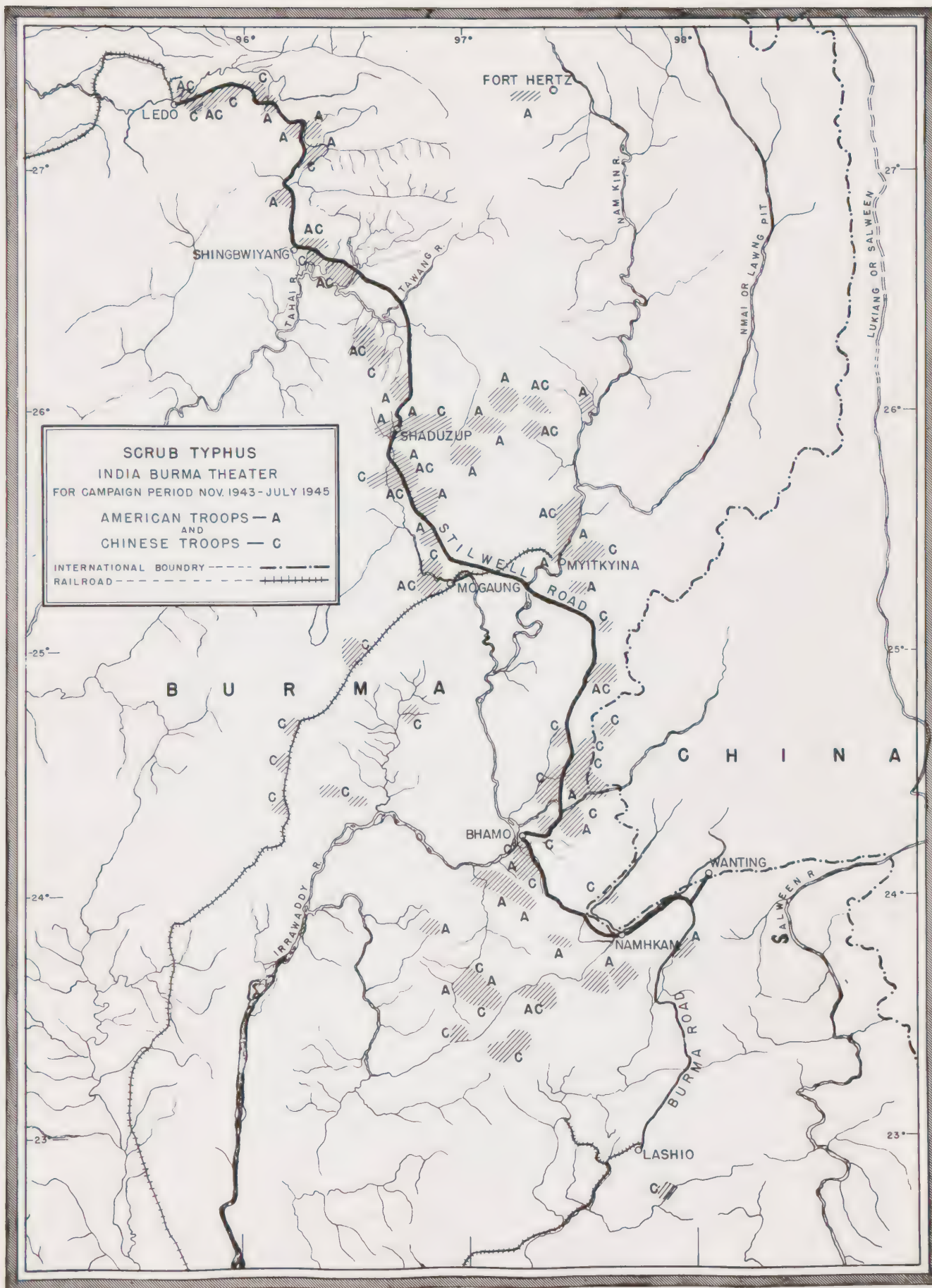
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Chart IV. Areas in which scrub typhus was encountered in wide-spread areas by staging and combat troops during the campaign in North Burma (adapted from USATC report, Dec. 1945).²⁸



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incidence, while the other three involved American troops in the main. A comparison by months is shown in Chart V for rates per 1000 per year in the SWPA and CBI Theaters.

Case incidence in the Burma experience was compiled by analysis of hospital records by a member of the U.S.A. Typhus Commission Burma team using diagnostic criteria of (a) Weil-Felix OXK titer of at least 1:200 or a rising titer in spaced serum samples, (b) a fever curve characteristic as to type and duration; plus consideration of certain clinical characteristics such as lymphadenopathy, presence of eschar and rash.²⁸ During the combat period of November 1943* through July 1945, there were in American troops, omitting 55 doubtful cases, 695 cases and 58 deaths from Ledo, Assam to the Namhkdm Trail in Burma (Table IV). In Chinese troops of the same combat teams and intermingled areas as seen in Chart IV, 403 cases and 40 deaths from the Ledo to Lashio areas, giving an overall mortality rate of 8.9 per cent in the total of 1098 cases in both groups handled in three American general and three evacuation hospitals.²⁹ Again, as in the Philippines, areas of high virulence were not encountered.

Data on certain of the early Chinese cases are incomplete, due to destruction of records of approximately 300 cases hospitalized in forward areas by the 25th Field Hospital, Seagrave's Hospital, and a detachment of the 151st Medical Battalion during action. The 44th Field Hospital later also handled forward cases during the siege of Myitkyina.

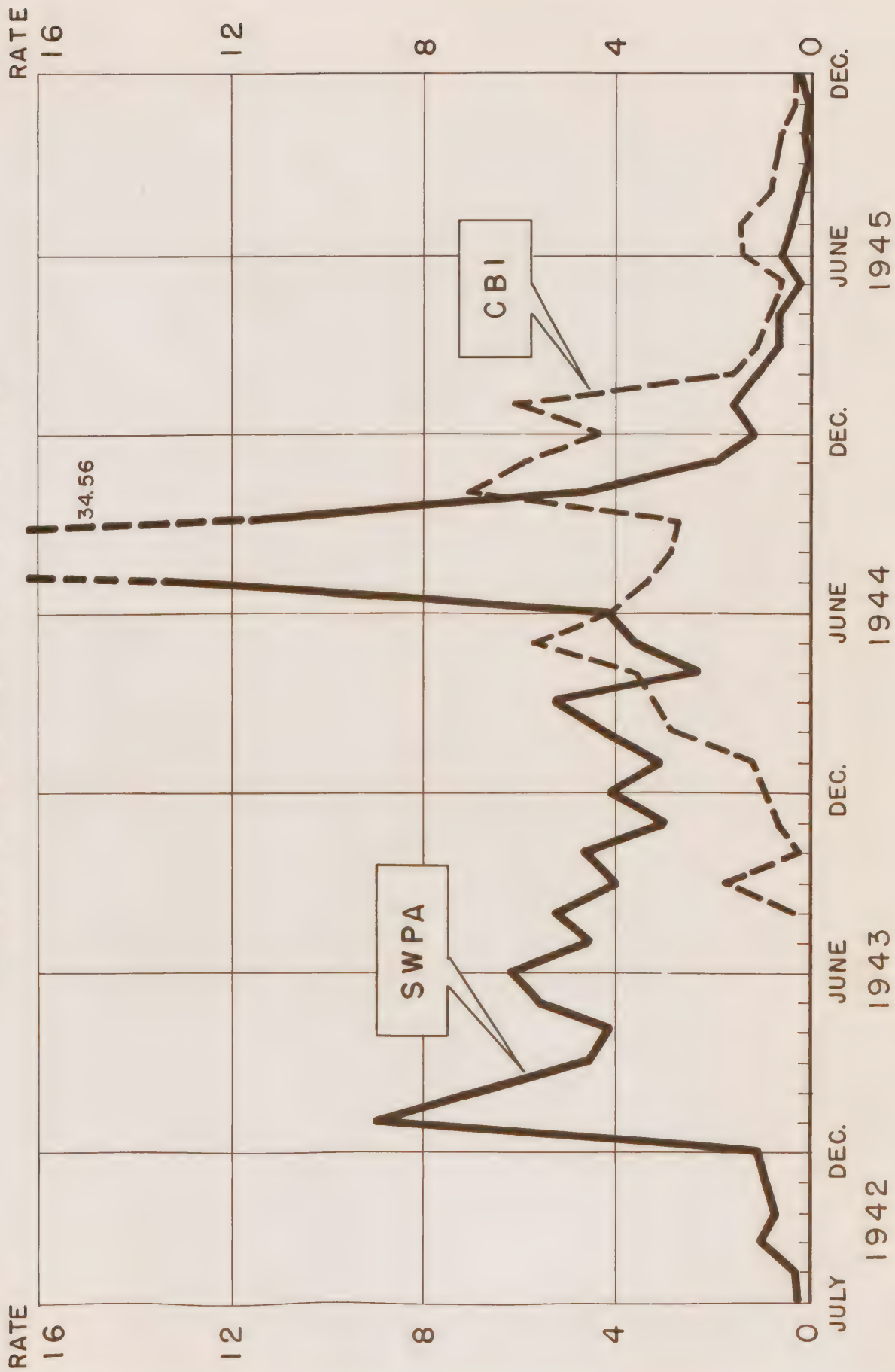
All but 66 of the total American cases and the bulk of the Chinese incidence occurred during what were considered as operational or combat

*One year earlier than separately reported for Burma-India by the Statistical Health Reports, Table IV.

Chart V. A comparison of case rates per 1000 per year in American troops in the Southwest Pacific (SWPA) and China-Burma-India (CBI) theaters. The high peak in SWPA in 1944 was due to the major epidemics in Dutch New Guinea mentioned in the text. The 5 peaks in the CBI curve were a reflection chiefly of combat activities.

SCRUB TYPHUS

RATES PER 1000 PER YEAR BY MONTHS



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activities rather than in Services of Supply operations.²⁷ Cases occurred in every month of the year, and the plotted curve of incidence in non-combat or service troops shows no correlation with the five peaks of incidence.²⁷ For example, all but 13 of the 189 American cases comprising the second peak came from the Galahad forces fighting their way toward Myikyina, the third peak comprised chiefly cases in the 5332nd Brigade "Mars Task Force" (composed approximately of 6000 American and 2000 Chinese troops) on maneuver and field training in a highly endemic area north of Myitkyina, and the fourth peak involved 194 American cases of which 185 were again in the above combat battalions of the 5332nd Brigade in the Bhamo battle area. The remaining 9 cases thus were scattered among the remainder of the 65,000 American troops in Assam and Burma not in active combat in January and February 1945. It was considered therefore that these peaks of incidence were a reflection of field exposure during combat and staging operations rather than a reflection of seasonal factors. This lack of observable seasonal variation was in agreement with observations in the New Guinea and Philippine episodes also, though the limiting exigencies of mobile military operations with consequent fluctuating exposure had to be kept in mind in such attempted evaluation.²⁷ Though British investigators reported their belief that there was a seasonal relationship to the incidence in their troops in Burma, there was no way to be sure that the same factor of exposure was not the responsible cause also.⁸³

TABLE IV
SCRUB TYPHUS

Hospital Admissions Nov. 1943 to July 1945 Incl.
India-Burma Theater, with Strength Reports
for Ledo Area and Burma where all of the
cases occurred. AMERICAN only.

Month	No. cases	Deaths	Strength	Rate/1000/annum
Nov 1943	3	0	*	*
Dec 1943	15	1	*	*
Jan 1944	6	0	25990	2.73
Feb 1944	3	0	27101	1.29
Mar 1944	2	0	27000	0.88
Apr 1944	32	2	27919	13.82
May 1944	137	25	28454	57.54
Jun 1944	22	0	29351	8.97
Jul 1944	24	0	32823	8.64
Aug 1944	21	1	35029	7.05
Sept 1944	34	1	39817	10.20
Oct 1944	107	3	43429	29.53
Nov 1944	75	2	50413	17.10
Dec 1944	59	2	57118	12.03
Jan 1945	143	17	65243	25.74
Feb 1945	6	0	69571	1.00
Mar 1945	1	0	71522	0.16
Apr 1945	0	0	70912	0
May 1945	1	0	67394	0.16
Jun 1945	2	2	56103	0.40
July 1945	2	2	54949	0.43
	<hr/> 695	<hr/> 58		

*Not Available.

Based on Survey of U.S.A. Typhus Commission

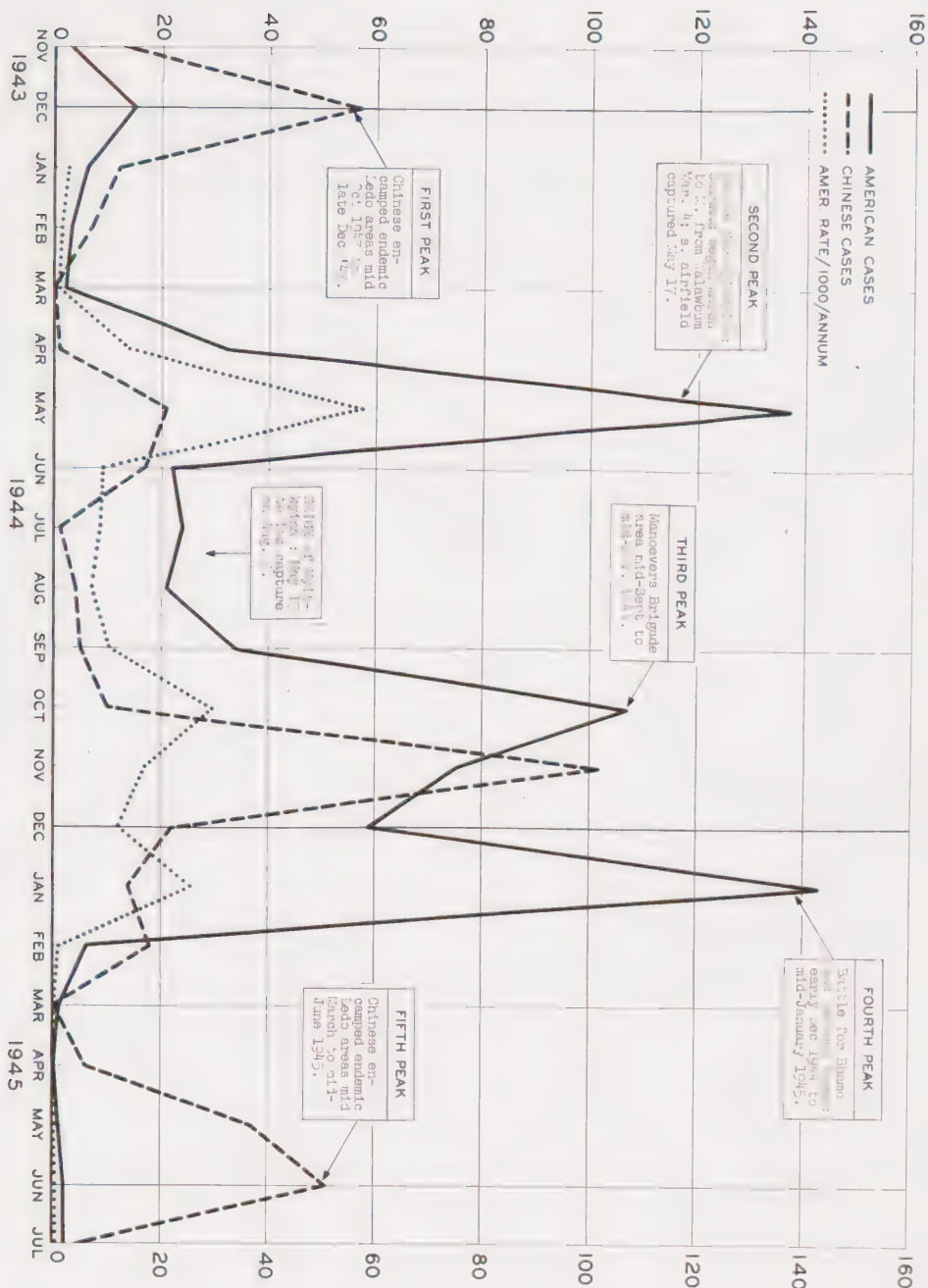
The rate curve (American troops) is seen essentially to follow incidence curve (Chart VI). Accurate Chinese strengths were not available but it was known that probably more Chinese combat soldiers were engaged in the Burma campaign than there were American. Five numbered Chinese divisions were involved.²⁸

The first case of so-called "CBI fever" was reported to the base surgeon at Advance Section No. 3 in Ledo, in December 1943, when the first peak of cases involving mainly Chinese troops in the Ledo and Shingbwiang areas was already well established. Although scrub typhus was suspected by the medical officers in these advance operations, they were understandably cautious in applying this diagnosis in a new region in the absence of supportive serology. So the early cases were reported under the subriquet of "CBI fever," or simply PFC. The early picture also probably was complicated by occurrence of some louse-borne typhus in Chinese troops being flown in from China as "delousing procedures were routine and necessary and louse-borne cases in the Chinese ran continuously through the campaign."²⁸

The fifth peak in June and July 1945, was more or less a repetition of the first in December 1943, since it again involved mainly Chinese troops staging in many of these same endemic areas, the so-called Nanchik encampment area and the 12-to 14-mile marks on the Road (Fig. 3 shows an air view of the 12-mile encampment focus with arrow pointing to the swimming area on the grassy banks of which cases from the 2 encampments were presumably infected, Fig. 4). Recognition that infected mites persist in a developed area for longer than a year was emphasized as a result of this experience.²⁷

Chart VI. Scrub typhus in India-Burma Theater, 1943 to 1945. Case incidence in American and Chinese troops, and rate in American troops only. The 5 peaks of incidence occurred in association with the military operational activities indicated (Mackie et al, 1946).²⁷

SCRUB TYPHUS INDIA BURMA THEATER



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Figure 3. Air view of Mile 12 focus of scrub typhus on Ledo Road. Arrow indicates bathing site, the grassy banks of which (see figure 4) were considered to have provided exposure of the two units staging on either side during the fifth (1945) CBI peak of the case occurrence.²⁸ The characteristic Burma rain forest is broken only by occupied or developed areas, or by secondary vegetational growths in abandoned bivouac sites (across the road) previously occupied during the 1943 peak of cases. Natural, open, grassy fields were not encountered until the approaches to Myitkyina.

(Air Forces photo - declassified)



Figure 4. Bathing site on Tirap River shown on figure 3.
Exposure to mites on grassy banks is illustrated here.
(M & MAS Neg. No. A45732)



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With the advent of the second peak it became evident that special attention to preventive measures was necessary, and on 31 July 1944 the Theater Surgeon sent a radio message to Field Headquarters, USA Typhus Commission in Cairo, Egypt, for any assistance they could provide. The Director, USATC, Washington, then assigned a field party to the theater, the first contingent of which arrived 21 October 1944. The chronology of their activities has been documented.²⁹ In that report graphs are presented comparing data of case occurrence from the special USATC report²⁸ and from 86ab reports. Discrepancies in totals and time distribution are due to elimination of some doubtful cases and plotting by actual onset in the former, among other differences in handling of the data.

Previous to the arrival of this special team investigative work had been initiated through the office of the Theater Surgeon, with certain basic studies being carried on at the 25th Field Hospital.^{87,88} One officer and two enlisted men received Bronze Stars for these studies. The USATC group reached an eventual strength of 14 officers and 36 enlisted men on or attached to the team, which functioned chiefly in investigations of epidemiology and etiology of the disease discussed later.²⁷ Among these personnel there were 14 awards of the USA Typhus Commission medal for meritorious contributions to the study of typhus during the Burma campaign.

Because of the probability that at least some of the listed admissions of reported scrub typhus in China (Table I) had been infected during staging in Burma and flown over during their

incubation periods, a clear picture of the actual focal conditions in China is not yet possible. As late as May 1945 a JICA report of typhus in civilians states "some of the cases occurring in Kweichow and Yunnan in a few respects resemble scrub typhus (OXK mite-borne type) but the presence or absence of this type of typhus fever in China has not yet been fully determined."³⁰ However, in late 1943 there is record of an American soldier hospitalized in the 100th Station Hospital, Delhi, India, three days after onset of symptoms and six days after being flown over from Kunming where his actual exposure must have taken place. He later presented positive serology "antigenically similar to the 'Karp' strain from New Guinea."³¹ In regard to focal areas in the Chinese area of operations, one other reference dated 2 May 1945, has been located: "Since 1940 the National Health Administration has knowledge of only five authenticated cases. Four of these were encountered in Kweiyang and one in Kunming."³²

Of the total of 94 typhus cases listed from China in Statistical Health Reports 18 between June and November 1945 were specifically reported as scrub typhus. Data on the actual sources of infection, however, still remain in doubt, and the authenticity of any cases in American troops originating in China was seriously questioned by the Medical Consultant of the China Theater Surgeon's Office who believed the typhus reports from that area to concern chiefly endemic (murine) typhus fever.³³

V SCRUB ITCH CAUSED BY TROMBICULID MITES

"Scrub itch, or chigger bites" constitute the only other affliction caused by trombiculid mites# to which troops were exposed in the areas under discussion so far as is known. We are not aware of any actual hospitalizations due to scrub itch alone, but in some areas of New Guinea such the Buna-Dobadura, Finschhafen, and Sansapor localities, severe reactions due to heavy chigger infestations were often suffered in troops during jungle combat or exercise.^{11, 17, 18, 46}

In this case, the reactions were of two types; those due to direct irritation of the bites and those which became secondarily infected due to subsequent scratching and abrasions. Figures are not available on the number of troops reporting to sick call or confined to quarters from this cause, but many cases are known to have occurred on the three bases listed above.* In SPA, scrub itch was encountered on Stirling in the Treasury Islands, and in the Munda campaign on New Georgia.³⁴ (see also discussion page 8).

The species of mites responsible varied in different areas. In northern Queensland (Fig. 11), where a few American troops were bothered, the species concerned was Trombicula "minor" (= buloloensis)³⁵ while that and two others, namely Schongastia blestowei and S. pusilla (Fig. 24), were responsible in New Guinea depending on the locality.^{11, 18}

#Scabic mites, which produce the dermatologic condition known as scabies, spend their entire life as obligatory parasites on their host and are only distantly related to trombiculid mites to which this history is restricted.

*Considerable annoyance was caused troops on maneuvers in some parts of the southern United States, as well as in Trinidad and Panama, according to verbal reports of several observers returning from those areas.

An undescribed species of Trombicula was the offender on New Georgia.³⁶ None of these species was a known vector of scrub typhus, though not entirely free of suspicion (see Sec. VII). Unlike the latter disease, in which the victim was seldom aware of the bite which caused the infection until or after the eschar developed during the incubation period of several days when the responsible mite had disappeared, the irritation set up by even a few scrub-itch producing bites developed within 24 hours around the attached chiggers and often persisted for nearly a week in uncomplicated cases.⁶⁰

It was remarkable that no reports of scrub itch were forthcoming in troops during the campaigns in the Philippines²⁶ and North Burma.²⁷

VI THE ETIOLOGY, EPIDEMIOLOGY AND ECOLOGY OF SCRUB TYPHUS AS OBSERVED IN THE ARMY EXPERIENCE

Numerous field and laboratory studies have been brought to bear on the adequate identification of the disease as encountered in various areas with infection caused by Rickettsia orientalis, the agent of Japanese tsutsugamushi disease. Evidence accumulated (as documented in Army contributions) has consisted of clinical and pathological data,^{11,26,27,37} serological studies^{2,26} using both the Weil-Felix (GK) reaction³⁸ and specific complement fixation,* recovery of strains of Rickettsiae from human, rodent, and mite sources and their comparative studies in laboratory animals,^{11,18,26,27,39,40,88} and identification of the mite vectors.^{11,18,27,41} Laboratory studies in the different theaters were carried on usually in hospital laboratories or Army Medical Labora-

*Using antigens prepared from New Guinea and Burmese strains of human origin and serums from Japanese recovered patients, serological studies confirmed the identity of the disease in these three widely separated areas.²

tories according to location (Fig. 5). Field studies were frequently conducted under trying and difficult conditions, both from a technical standpoint (Fig. 6), and in relation to task force perimeters, and other combat hazards (Figs. 7 and 8).

The ecology of the disease in certain respects followed to a remarkable degree that of another acarine-borne rickettsial disease, namely, the Rocky Mountain spotted fever group of rickettsioses. It showed the same peculiar place localization or "spottiness" distribution in certain areas. Adjoining companies occupying the same kunai grass flat in the Labura staging area and other localities in New Guinea under the same environmental conditions with relation to the surrounding sharp jungle margins sometimes showed remarkable differences in incidence between them, or in comparison to adjoining units with similar activities and apparent comparable exposure.^{11,19}

For example, the early fighting of the West Visayan Task Force on Mindoro was through fields of tall grass in which focal areas of infection were encountered (Figures 9 and 10).²²

"The greatest number of cases, namely, 25 (of 70 total at the time) occurred in the 803rd Parachute Infantry, 16 of these in A Company alone. Of these, six occurred in the 3d Platoon of A Company. Questioning of these cases disclosed the interesting fact that five of the six were in the same split squad. The other half of the same squad in which no cases occurred and which operated separately was approximately 200 to 300 yards away at all times during the first 10 days of the operations on Mindoro" (i.e., the incubation period).

This was also strikingly illustrated at Sansapor where certain platoons of the 1st Infantry Regiment bivouaced in War Village (Fig. 41) were especially heavily hit.¹⁷

This localization of foci was encountered in all three major episodes discussed above^{11, 18, 20, 27} and was found in the classic tsutsugamushi areas in Japan as well.² It was visualized as possibly



Figure 5. Interior view of USA Typhus Commission field laboratory at the 3rd Medical Laboratory, Dobadura, New Guinea during miticide studies.
(M & MAS Neg. D44151)



Figure 6. Example of "laboratory work" at an Army field station set up on Bat Island, Purdy Group, where high endemicity of scrub typhus caused previous military abandonment of the outpost. Mites from native rats are being injected into white mice, which later became infected.
(USATC Neg., GMK)



Figure 7. View of distant Biak Island, Dutch New Guinea during bombing of Japanese-held caves in the coralline ridges near which mite surveys were concurrently conducted in connection with the Owi-Biak epidemic of scrub typhus.
(USATC Neg., CBP)



Figure 8. Mite survey of the embattled rainyslopes of Mt. Mandalagan, Negros Occidental, Philippine Islands, near the forward perimeter during combat. Foxholes and other mite-exposed positions among the kogan grass and ferns of this ridge resulted in cases of scrub typhus among American and Philippine troops.
(USATC Neg., CBP).

Figure 9. Catching rats in a field of young Saccharum grass near San Juan, Mindoro, Philippine Islands through which the 503rd Parachute Infantry fought and were infected with scrub typhus. The height of mature grass is seen in background.

(M & MAS Neg. D44398-4)



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Figure 10. Rat burrows at base of **Saccharum** grass in abandoned cane fields, Mindoro, Philippine Islands. Ground cover for mites was sparse and dry but trapped rats carried large numbers of attached mites.
(M & MAS Neg. D44398-3)



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related to more restricted foraging and familial movement in a given environment among local rodent populations carrying infected mites than had been supposed as habitual among field rats and allied small animal hosts.⁴¹ Otherwise there seemed to be no ready explanation for such marked focal restriction.

Different levels of virulence in various foci were apparent as evidenced by differences in mortality rates, discussed in previous sections, another point of resemblance to Rocky Mountain spotted fever. These differences were more apparent when individual outbreaks were considered rather than a consideration of the over-all rate for a given base or area command. A report of cases hospitalized in the 161st Station Hospital at Base F (Finschhafen) Southwest Pacific relates:²⁰

"There were 6 deaths in the 38 patients who contracted their disease on this Base, and all the deaths occurred in one unit having 16 cases over a period of 3 weeks. Hence the mortality for this particular unit was 37.5 percent, which is the highest mortality thus far reported in this theater and served to emphasize the marked variability in the virulence of the various outbreaks in the same as well as in different localities of the New Guinea Archipelago. Another index of the virulence of the outbreak in the units having the 6 deaths is that 5 of the 10 that survived had to be evacuated to general hospitals."

Of interest by way of contrast in virulence is an extremely mild case from the same battery having the most cases in this small outbreak. This patient was hospitalized with a 2-day fever and later discharged as "PUC" with no other symptoms; while on full duty 21 days later a sample of his serum gave a positive Weil-Felix titer.⁴²

In extreme contrast to the high virulence in the classical areas in Japan with reported mortality rate of 35 to 60 per cent is the very low rate of 0.06 per cent in the extensive Owi-Biak focus. In a few

instances in this epidemic initial symptoms were so mild as to result in discharge of early patients as FUC followed almost immediately by readmission with frank symptoms.¹⁴ This was further supported by recovery of 8 strains of the disease agent from patients, 4 of which "failed entirely to kill groups of mice, and on further study the other 4 ... produced milder infection in laboratory animals than strains isolated in other outbreaks."⁴³

There was no evidence in any of the episodes discussed above that the disease had a seasonal cycle such as it has in the temperate climate of Japan.¹¹ On the contrary, cases were contracted in Army personnel in every month of the year in New Guinea, the Philippines, and Burma. Outbreaks resulted from the fortuities of exposure under the exigencies of military operations and the penetration of primitive areas.

This was especially clearly demonstrated in the Burma campaign where outbreaks occurred in 5 major peaks each related to special combat or staging activities and were not seasonally distributed except as the wet or monsoon season curtailed both movement and exposure.²⁷ In the Oro Bay-Dobadura Base on New Guinea after the termination of the Buna campaign in January 1943, sporadic cases continued to crop up in the endemic areas for over two years as troops completed training and replacements of new staging troops resulted in continued exposure during patrols and "jungle exercises" regardless of the time of year.⁶⁰ On the other hand, the extensive Owi-Biak focus ceased within a year to provide new infection after the final elimination of scattered enemy elements in the interior of Biak and adjacent Saipuri Islands, and the consequent cessation of exposure to mite-infested areas on combat patrols and details.⁴⁴

Types of focal environments varied as new episodes were encountered and it became increasingly clear that there was no such thing as a "typical scrub typhus area." Early in the New Guinea campaign over-emphasis was placed on "kunai grass" because that was the apparent predominant source of infection in Papua and British New Guinea.⁹ Then came the Bat Island⁴⁰ and Iutch New Guinea¹⁸ episodes adding neglected coconut plantations (Figs. 31, 33), abandoned native village and garden sites (Fig. 41), and margins of climax rain forests to the list of typhus loci, followed on Luzon by cases from mountain scrub areas as high as 3,000 feet altitude,²⁶ and even from within the rain forest itself in Northern Burma, and possibly Owi Island (Figs. 39 and 40).

Figures 8 to 17 show grassy areas in Northern Australia (scrub margins), New Guinea (kunai), Philippine Islands (Saccharum and kogan), and Ledo vicinity, Burma (Paspalum) where cases originated. For comparison focal areas of "yoshi" grass in the classical endemic Prefecture of Yamagata, Japan, are shown in Figures 18 to 20. There appears to be no satisfactory ecological explanation for the kunai flats and ridges with their margins sharply delimited from dense jungle rain forests in New Guinea (Fig. 21). The Saccharum through which the 503rd Parachute Infantry fought above Mindoro beaches at San Juan was a dense secondary invader in abandoned canefields (Fig. 9). In contrast, the kogan grass and ferns on the slopes of Mount Mandalagan (Fig. 8) in the margins next the timberline of which the troops of the 160th Infantry and 503rd Parachute Infantry dug their perimeter foxholes, was a primary growth with open grassy spurs extending into the timber along the ridges. All seven Negro cases were contracted here, and none in the 10-mile stretch



Figure 11. Grassy margin of gum-tree scrub on the Atherton Table Lands, Northern Queensland, Australia. Typical habitat of Trombicula minor where cases of scrub typhus and scrub-itch originated during staging exercises. (USATC Neg., GRP)



Figure 12. Method of close observance of activities of mites on grass stems in area of concentration shown in figure 11.
(USATC Neg., CBP)

Figure 13. Kunai grass in New Guinea, supplying ideal
cover for mites and their rat hosts.
(M & MAS Neg. 80 144)



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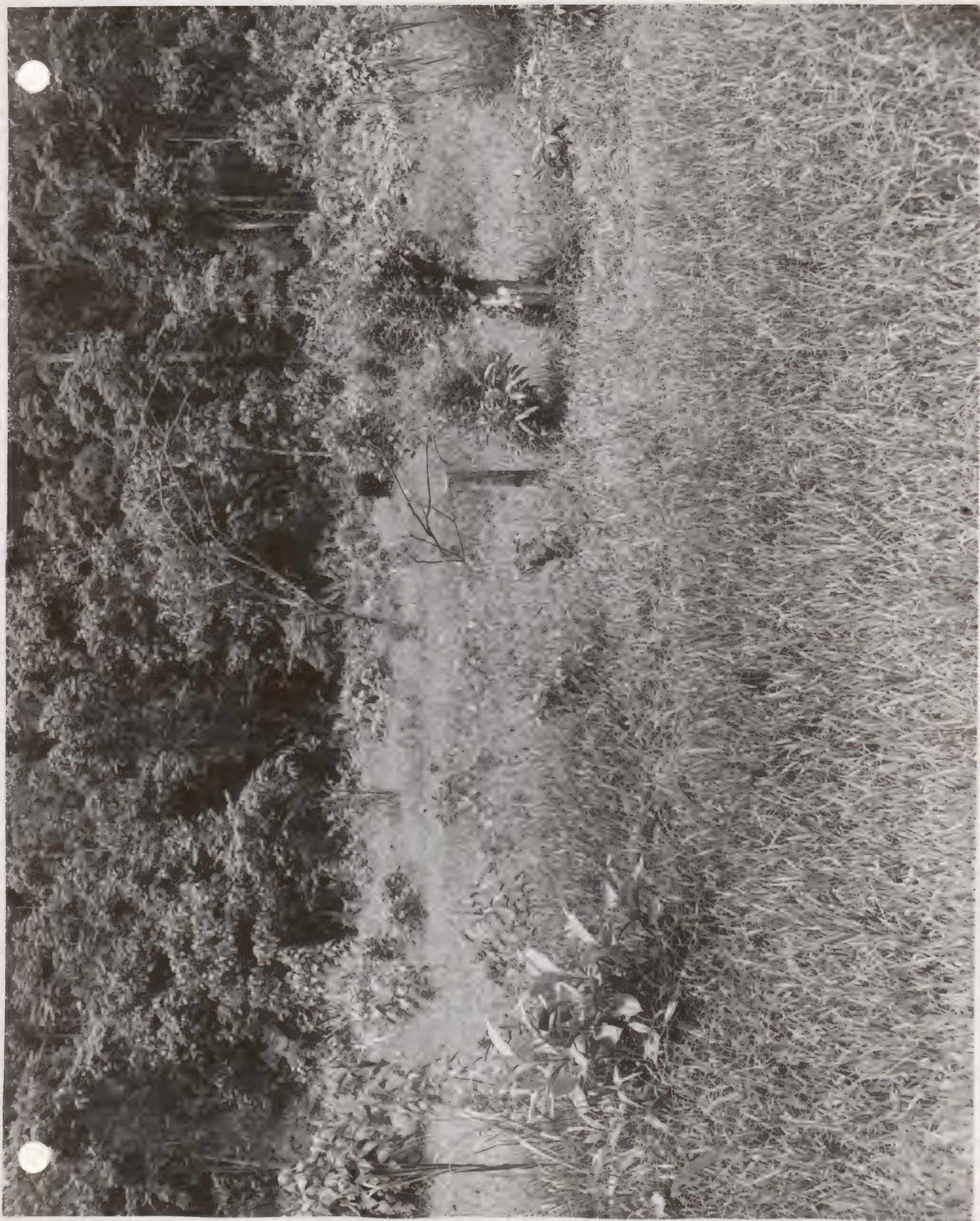


Figure 14. Young kunai grass, secondary growth in abandoned camp site of 375th Troop Carriers with sego swamp and rain forest in background. Both vector species, Trombicula "fletcheri" (akamushi) and deliensis, were taken in host collections here where an epidemic of scrub typhus occurred.
(USATC Rep., GME)



Figure 15. Hmsei grass in bloom in old camp area near
Dobadura, New Guinea.
(USATC Neg., GW)

Figure 11. Young secondary growth of Deguelum confucium grass
in abandoned camp site, Ledo Road scrub typhus focus at
Mile 20.
(M & MAS Neg. A 45732-12)



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Figure 17. 3rd Tank Battalion area, Iodo Road mile 12.4 focus, 4 months after abandonment.
(USATC Neg., ROB)



Figure 18. "Toshi grass" on banks of Nagami River, classical tsutsugamushi disease focus, Yamagata Prefecture, Japan during occupation of the 11th Airborne Division.
(USATC Neg., CBP)



Figure 19. Closeup of "susuki grass" (Miscanthus sinensis) on island in Agano River, Niigata focus of disease, Japan, showing similarity of rat and mite cover to New Guinea kunai grass.
(USATC Neg., CBP)



Figure 20. Virulent focus in classic tsutsugamushi area of endemicity along the Mogami River where annual mortality up to 60 percent has been recorded. Harvested grass is shown on the dike in the right foreground.
(USATC Neg., CBP)

Figure 21. Air view of ~~Embi~~ Lakes focus, Dobadura,
New Guinea, showing peculiar kunai grass open areas in
rain forest, the margins of which are usually sharp,
with no ecologic explanation.
(SC Neg. 230756)

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of fields below to the beach, much of which closely resembled the Mindoro focal areas, and through which considerable fighting and consequent exposure also occurred.²⁶

This variation in environmental types emphasized the unpredictability of potentially infected areas except as surveys revealed the presence of rat- and man-infesting mites as summed up in the following statement:¹⁸

"Within any environment which constitutes a focus of infection lies the fundamental mechanism of natural maintenance, the rat-mite-rat cycle. This conceivably can function under local ecological conditions suitable to the developmental requirements of the mite vectors. Various species of rats are ubiquitous in the regions under discussion. This is stressed because false reliance on a given environmental type as the dangerous one has already misled some recent units that had experienced the disease in previous kunai locations, resulting in a relaxation of vigilance under the new changed surroundings. Wherever man is attacked by rat-infesting mites in the Southwest Pacific region there is the possibility of infection. Not all mites that attack troops, notably scrub-itch mites, are common parasites of rats. The disease is thus focally distributed because of the necessity that both the rat-mite species and the rickettsial agent be present together to result in human infection." (Chart VII)

Cases attributable definitely and solely to tropical or primary rain forest were not encountered in New Guinea,^{18,48} but in Burma this appeared to be the only possible source of infection in a very limited group of troops,^{82,83} and the vector species of mites was encountered in camps from such an environment.⁸³ However, some cases in some units during the epidemic on Owi Island are presumed to have become infected during the clearing and location in dense, climax forest (Figs. 39 and 40), though contact with more open beach areas obviously could not be ruled out.

VII THE MITE VECTORS AND ANIMAL RESERVOIRS OF SCRUB TYPHUS IN SOUTHWEST PACIFIC AREA AND CHINA-BURMA-INDIA

In Chart VII is depicted what was believed to be the diagrammatic

Chart VII. The theoretical rat-mite-rat cycle of scrub typhus in nature was diagrammed in one report.² The "rickettsial stream" is continuous from generation to generation of chigger mites with new lines started from infected rats. Soldiers were accidental intruders in the cycle. (MB MAS Neg. 93587)

scheme of the "rat-mite-rat" cycle of the disease agent as it is maintained in nature, and the accidental infection of man.² Contributions by Army personnel to our fundamental knowledge of vector-reservoir relationships have come from many sources in the Medical Department including observations and/or collections by malaria survey and control detachments;^{5,45,46,47,48} medical officers of hospitals,^{20,49,88} medical laboratory, administrative, and combat unit staffs,^{12,15,18,22,49,83} and scrub typhus investigative teams in both SNPA and CBI sent out from the United States of America Typhus Commission.^{2,11,18,26,27}

These studies and observations abundantly amplified information that man is accidental host rather than an essential host in the disease cycle as he is in malaria. They also provided the first conclusive confirmation of transovarial transmission (adult to progeny) of R. orientalis in laboratory reared mites.^{27,50}

Two species of mites were demonstrated as actual carriers of infection, namely, Trombicula akamushi (under its synonymic or subspecies name T. fletcheri)^{11,18} and T. deliensis.^{27,40} The last had been strongly suspected previously in other areas, but it was first definitely proved in connection with the Bat Island (Admiralty group) epidemic in SNPA (early reports used its synonymic name T. walchi).¹⁸

The two species are very closely related morphologically (see Figs. 22 and 23) and intergrades or variations in certain systematic characters in mites of the akamushi-deliensis complex from certain areas in Dutch New Guinea, the Philippines,⁴¹ Burma,²⁷ and Japan,² led to some taxonomic confusion in the absence of adequate rearing techniques. In other foci, identifications of "fletcheri" (akamushi) and deliensis were readily made without these confusing variants being present.¹⁸ Identifi-



Figure 22. Microphotograph of Trombicula akamushi, the classic mite vector of tsutsugamushi or scrub typhus (reported as T. fletcheri in early reports from New Guinea.)¹¹



Figure 23. Microphotograph of T. Heliensis, the other proved vector of Army studies (also called T. walchi).¹¹

ocations of various Army collections in the main were made by Mr. H. Womersley, South Australian Museum, Dr. H. E. Ewing of the U. S. National Museum, Lt. H. Wharton (USNR), and the entomologists of the UNRHC scrub typhus teams.^{18,20,27} Final clarification of the specific components of this vector complex were considered as not yet possible at the close of hostilities⁴¹ though akamushi from the classical endemic areas and mite hosts were made available after occupation of Japan.²

During these studies, five strains of Rickettsia orientalis were isolated in laboratory mice from naturally infected mites in New Guinea^{11,18} (Fig. 6) and 53 in Burma.²⁷

T. deliensis was reported by American Army personnel from northern Queensland, many places in New Guinea, the Philippines, northern Burma, and the vicinity of Kunming, China.⁵² This species alone appeared responsible for the Bat Island and Pinschhaven (New Guinea), Mindoro and Samar (Philippine Islands) epidemics and many areas along the Stilwell (Ledo) Road previously discussed. Outbreaks which could have been caused by either or both deliensis and akamushi (fletcheri) according to local mite surveys were the Dobadura area, Owi-Biak, and Sansapor (New Guinea), Luzon and Negros (Philippine Islands) and certain northern Burma localities.

Hosts of the vector species as found in various Army studies have included a wide variety of animals: rodents,^{2,18,27,41} marsupials,¹¹ insectivores,^{27,52} birds^{27,40} and man.

In addition to this proven vector group, certain other species that were found in a few focal areas on both rats and man were placed under suspicion. These included two species of Trombicula, wichmanni and acuscutellaris.⁴¹ The itch mites, T. buloloensis or Schongastia

species (Fig. 24) were on occasions the only species found on careful survey following outbreaks in both American and Australian forces in New Guinea.^{12,35} ⁴¹ One report stated:¹⁸

"In the early experience, patients hospitalized for mite-borne typhus seldom gave a history or exhibited the lesions of scrub itch on admission. At "E" (Sansapor), however, both conditions not infrequently occurred in the same patients showing that exposure to the itch-producing species had occurred probably during the incubation period. In such cases careful discrimination may be required to differentiate the true primary eschar. Numerous specimens of Achoengastia were taken simultaneously with Trombicula walchi Womersley and Heaslip 1943 in a focus of intense infection (Sansapor), both in boot-collections and on rats. They therefore come under definite suspicion as potential vectors in the area."

However, in most instances scrub-itch producing species were believed not to be transmitters in consideration of differences in customary location of the lesions and in local host preferences for hosts other than rats.¹¹ Probably in excess of 75 new species in over a dozen genera of mites collected from a wide variety of cold-blooded and warm-blooded hosts, both birds and animals, have been or are in the process of being described as a result of intensive, though necessarily often rapid, survey work by various Army agencies during field operations in SWPA and CBI.

Data from these epidemics in Army episodes did not reveal any necessity for suspecting transmission by arthropod species other than trombiculid mites, though at various times writers as recently as 1944, made suggestive reference to the need for considering local species of ticks in connection with scrub typhus infection. Species of ticks were taken in several surveys incidental to mite studies¹⁸ but not under circumstances requiring their serious consideration as vectors. The only place reporting any considerable number of tick bites in areas under



Figure 24. Microphotograph of Schonastia pusilla, one of the chiggers causing scrub itch in troops.¹¹



Figure 25. One of the important mite hosts in New Guinea, a rat-like marsupial known as the bandicoot, Bandicota cockerei, often seen in Army installations at night.



Figure 26. Two species of important mite hosts in New Guinea. The smaller, Rattus browni, was found to be naturally infected, and with the larger, R. mordax, were the commonest carriers of vector species of mites.

(USATC Neg., CBP)

Figure 27. An excavated nest of the Japanese vole, *Microtus montebelli*, the important, local animal reservoir of tsutsugamushi disease. No mites were found on these young, though their mother was heavily infested.
(SC Neg. 216301)



27

SP 2

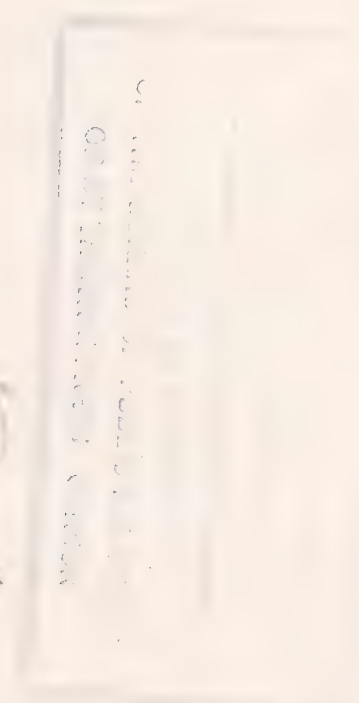


Figure 28. Japanese farmers digging out voles in
mite surveys in Niigata, Japan. Supposed "mite-
tight" clothing was only protection from mite-bite
used by natives.
(SC Neg. 216304)



214304



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Figure 29. New Guinea natives catching rats in pits during mite surveys at Dobadura, New Guinea.
(USATC Neg., CBP)



Figure 30. Another type of live rat-trap employing a buried 50-gallon oil drum with baited sticks for mite surveys of infested rats.
(M & MAS Neg. D-45398-2)

present discussion was during the early fighting near San Juan, Mindoro.⁵¹ Parasitoid mites of several species were present on rats in all areas surveyed. No known attacks on troops by these mites occurred, and their possible role as vectors between rats in nature was unknown.⁶⁰

No evidence was elicited of any important "animal reservoir" of the disease other than rats in the various episodes studied. Because of certain prewar observations in northern Queensland and New Guinea, concern was felt in the early days of the New Guinea campaign regarding bandicoots (Fig. 25), a common rat-like marsupial, often seen about bivouac areas. However, they were not found to be susceptible during laboratory experiments.¹⁸ On the other hand, strains of infection were recovered from two native-caught Rattus browni (Fig. 26) near Bobadura,¹⁸ and from 8 R. flavipectus in northern Burma.²⁷ R. praetor came under strong suspicion as playing a part in the disease focus encountered at the Cape Torokina beach head on Bougainville Island.⁹⁰ That susceptibility is not confined to Rodentia, however, was shown by recovery of natural infection from 4 Insectivora, Tupaia belangeri, the Assamese tree shrew.²⁷ The persistence of infection in certain tissues of experimental rats for periods up to at least 98 days is a further fact of fundamental importance adduced in an Army field laboratory.¹⁸ (Figs. 27 and 28)

Many species in several genera of rats, both domestic and native or wild, were taken by various Army agencies in connection with mite surveys, particularly in endemic areas. (Figs. 9, 27, 28, 29 & 30). Tentative determinations of species captured were sometimes made in the field,

but for authentic identifications, stuffed or alcoholic specimens were sent to Mr. E. Troughton of the Australian National Museum,⁵³ and to Dr. Remington Kellogg of the U. S. National Museum.⁵⁴ Such specimens have been catalogued and are available for further ecological and systematic studies by specialists in the groups.⁵⁴ At least one new species of bandicoot, and 7 new kinds rats were taken during the collection of mite hosts in SWPA.

Both domestic and native rats were found quickly to invade new Army installations often carrying mites. Mites on such animals or on camp pets such as dogs were of early concern but later not considered dangerous.¹⁸ These mites habitually attached in the protected folds of the outer ear of their animal hosts. The possibilities of transfer from such hosts to man were considered remote, as were the chances of detached mites continuing development in cleared camp areas or buildings to the parasitic, larval stage of the next generation, a matter of some weeks. However, before it was known that foci of the disease existed in the Philippines, transportation of dogs (potentially mite-infested) by plane from New Guinea northward was wisely restricted by the Surgeon of the Fifth Air Force.¹⁵

Domestic rats were also found to move inland with Army operations, particularly during establishment of food dumps and quartermaster supplies.^{41,46} The terrain through which the Army generally operated in SWPA and Burma furnished ideal rat and mite cover in the ground litter, and exposure of troops to mite attacks was inevitable. The volunteer undergrowth in neglected coconut groves and abandoned native village sites was found to be particularly attractive to rats (Figs. 31 to 33). The rapidity of re-establishment of secondary growth in an abandoned



Figure 31. Undergrowth in neglected coconut plantations in the Saser, Philippine Islands focus, providing good rat and mite cover.⁴¹



Figure 32. The same area after burning with flame throwers showing ground surface of porous coralline formations.⁴¹



Figure 33. Coconut grove ground cover in the area of high endemicity on Sat Island.⁴⁰

Army camp-site in a focus along the Ledo Road is shown by comparison of Figs. 34 and 35.

Although refuse and careless garbage disposal, as well as abandoned Japanese food dump sites were found to attract a concentrated rat population, corresponding increases in mites in the relatively short periods of time involved were not observed.^{27,60} The occurrence of free-living, non-parasitic mites about such places sometimes caused confusion to the uninitiated sanitary personnel. Such mistaken identity of harmless forms seen in bulldozer trash heaps margining the non-grassy beaches of Uwi Island during the early phase of that epidemic caused a needless jurisdictional directive against bathing on the beaches.¹⁴

VII. ANTI-MITE MEASURES EMPLOYED DURING THE CAMPAIGNS IN SEPA AND CBI.

As discussed above, trombiculid mites were most abundantly encountered by combat forces in primitive rather than in agriculturally developed areas. Consequently the potentialities of mite attack were universal during the campaigns in New Guinea and northern Burma, more limited in the Philippines and during staging in northern Australia. During the early part of the action in each theater no special anti-mite measures were inaugurated other than the usual practices and vigilance exercised in good bivouac and camp sanitation which also contributed to mite reduction. These measures were merely intensified when an outbreak occurred during this early period. The following is quoted from report of the "Alamo" Surgeon after the Goodenough Island epidemic:⁵⁵

"The first epidemic of scrub typhus occurred from 1 November 1943 and lasted until 15 January 1944. During this period there were 75 cases with 19 deaths. The areas mainly indicted as endemic foci were the hospitalization area and Malauna Bay area. A rigid typhus control program was instituted and turned over to the malaria control and survey units for execution. They were aided by the Engineers, Quartermaster, Angau, and unit commanders."



Figure 34. Camp area of 1st Motor Transport Regiment, Mile 21, Ledo Road focus, immediately after removal. (U S WAB Neg. A-732-19)



Figure 35. The same area from different angle 4 months after abandonment. Note tent stakes still in place. Secondary growth rapidly reinvades the cleared area. (USATC Neg., RCB)

The officers and men of the 12th Malaria Control Unit and 3 personnel of the 6th Malaria Survey Unit received Bronze Star awards for typhus control work during this epidemic.⁵⁹

The help of such malaria units was increasingly enlisted as the campaign in SEPA progressed to aid in control programs formulated on the basis of studies by the USA Typhus Commission team, and other Army agencies.⁵⁶ In August, 1945, the following GNG directives were issued during preparations for the final assault on the Japanese homeland:⁵⁷

"The responsibilities, training and activities of all agencies concerned with control of malaria will be extended to include preventive measures directed against other epidemic diseases transmitted by insects and other animals."

In the fourth paragraph of a memorandum entitled "Training program in control of malaria and insect-borne diseases" are outlined responsibilities of such personnel for indoctrination of all Army personnel in the military importance of malaria and other insect-borne diseases in the following subjects:⁵⁸

- * Individual protection against mite(chigger) bites.
 - (a) Impregnation of clothes and blankets with Quarter-master Item 51-R-300 (Repellent, insect, clothing Treatment).
 - (b) Preparation of bivouac areas.
 - (c) Avoidance of mites."

As scrub typhus was encountered in increasing amounts and obviously widespread areas in the interim, special attention became focused on mite control, and it was corroborated that the customary clearing and preparation of camp sites was also effective in local mite reduction (Fig. 36). This was in part the basis for the later directives cited above. Rats trapped in well-cleared military areas gradually became practically mite-free, while rats taken in the adjoining jungle margins remained as heavily



Figure 36. A camp site stripped of all vegetational cover with tents raised on stilts was found best to eliminate both rat and mite cover. The 19th General Medical Laboratory Officer Area at Hollandia, Dutch New Guinea.
(USATC Neg., GBP)

infested as in previous samples. This was observed in the Dobadura, Hollandia, and other areas in New Guinea,⁶⁰ and confirmed in close quantitative sampling by the 60th Construction Battalion,⁶¹ 30th Malaria Survey Detachment,⁴⁶ and in Burma⁸³ during the Owi, Sansapor, and Ledo Road epidemics, respectively.

Effective reduction of mites by area clearing was also corroborated by comparative counts of mites crawling on boots of an observer squatting in various types of terrain including camp sites and adjoining unaltered grass, brush, or jungle margins (Fig. 37).¹¹ Figure 12 also shows a method of close observation of mites in the ground litter. In 1945 "ground area treatment for control of mites" with insecticide was also proposed but considered to be impractical for advance military operations,⁶² and in tests in the mite-infested New Guinea jungle, DDT plus oil was found not to be superior to the oil alone in reduction of mites, with relatively rapid replacement of the local mite population in the treated area.⁶³

On the basis of epidemiological observations of scrub typhus encountered under varying conditions through the New Guinea campaign, the following summarical account of the conceptions of control was published:¹⁸

"These considerations should serve as a guide for adaptation of practical control measures to the varying requirements of any current military operations. In the absence of a vaccine, these measures come under two headings, mite reduction and personal protection.

"In some beachhead areas, control work was integrated between Army and Navy ground forces such as in this "Sea Bee" and adjoining Acorn 8 units during the epidemic on Owi Island in July 1944. Accelerated clearing and impregnation of clothing was ordered after demonstrations by members of the USA Typhus Commission SWPA team (Fig. 46)⁸⁹

Figure 37. Method of "boot collection" for area sampling of mites, used to supplement surveys for mite vectors by rat trapping.
(M & MAS Neg., 80144)



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ACC. NO.

"It is not the province of this report to discuss these at length as we have observed them in the field. Briefly, mite reduction is the most practical and enduring measure where installations are relatively static, and consists of alteration of the environment to produce conditions unfavorable to moisture-sensitive mites in the soil surface. Clearing, burning, sanding and the like take time and machinery when available, more so in wooded areas than in open terrain. During the initial stages, therefore, while the grounds are being exposed and dried out, or with troops deploying in virgin environments, it is necessary to resort to protection of personnel.

"Hadden, Lindquist and Knipling (1944) at the Orlando Laboratory of the Bureau of Entomology reported initial studies on the use of insect repellents for protection from North American chiggers. Using modifications and a strict anti-mite field, Major R. S. McCulloch developed a program of hand-applied fluid in the Australian forces which has been followed in the field. A method of anti-mite clothing impregnation, using 5 percent emulsion of dimethyl phthalate in 2 percent soap solution, also has been developed by Capt. R. C. Busland of the USA Typhus Commission. Both of these methods have been under rigid study using thousands of mites (Fig. 38) and have been shown to be effective in reducing the incidence of scrub typhus. Both methods require strict supervision in the average units as a command function, especially during operations, but the 'human equation' makes hand application less reliable in our limited experience with this method. Systematic indoctrination has made it a successful practice among Australian troops, however. ... The most difficult to protect in practice are the foot soldiers on extended patrol in the hills or jungles where every ounce of weight carried is critical."

Unit area clearing was accomplished by various methods and with varying expeditiousness according to manpower and equipment available, and with acceleration when local emergencies demanded. (Figs. 39 and 40). Under the pressure of early logistical demands in a given beachhead or jungle operation, equipment such as bulldozers, graders and trucks were primarily needed in time-limited preparation for combat development of airfields, docks, roads and establishment of perimeters. Similarly, often in spite of known presence of a focus of scrub typhus, even manpower for hand-clearing of unit camp sites was available from pressing combat or operational duties frequently only in the early morning and late evening.^{23,64} Under these circumstances there was an understandable

Figure 38. Jungle laboratory for natural testing of clothing treated with different miticides during United States Army Transport Command studies at Dobadura. (M & MAS Neg., D44123)



Fig 36 p 39

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U. S. Army Medical Museum D-44123



Figure 39. Clearing virgin jungle with a heavy caterpillar tractor during the epidemic on Owi Island.
(USATC Neg., CBP)



Figure 40. Camp sites stripped from virgin rain forest on Owi Island with dozer trash-row between units. Cases in this unit probably were contracted from this environment.
(USATC Neg., CBP)

lag in continued occurrence of new cases in a given unit which did not have the supplemental protection of repellent-treated clothing.

On Owi Island the pressure to meet the logistical deadline for completion of operating airstrips and docks probably resulted in such continuation of case incidence in the 864th Aviation Engineering Battalion and other local units because of unavoidable delays in complete clearing of their respective unit areas and delay of arrival of emergency supplies of repellent for clothing treatment (Table V)^{18,64}. Figures 39 and 40 illustrate the dense vegetational cover on this Island that impeded units having to do clearing by hand only.

Due to an initial shortage of cots, units of the 1st Infantry Regiment were still sleeping on the ground at native-abandoned War Village (Mansaper epidemic) on D-day plus 13, by which time there were already 135 cases hospitalized, and in spite of institution of vigorous clearing and burning (Fig. 41), cases continued to pour into local hospitals in part due to lag in onsets of men already infected.¹⁷ The fact that cases already incubating the disease continued to occur for at least two weeks in a given epidemic even if theoretically every subsequent mite-bite could be prevented, was often difficult to impress on unit commanders busy with various other combat responsibilities.¹⁷

In the later studies in New Guinea and Burma it became evident that a potentially dangerous area could be rather quickly determined if either of the vector species of mites were found in the ears of locally trapped rats. In the Burma observations²⁷ a correlation was shown between a high percentage of indigenous I. deliensis in local mite surveys and so-called "hyperendemic" foci of the disease, as corroborated by recovery of strains of disease from local mites by injection of laboratory animals.



Figure 41. Mite control during the Sansapor epidemic, by burning and clearing in a highly endemic area (Mar Village) used for bivouac by the 1st Infantry Regiment which was rendered ineffective by scrub typhus. (USATC Neg., CBP)

TABLE V

Weekly incidence of cases by onset in certain units during
a scrub typhus epidemic on Owi Island, New Guinea

Incidence by weeks ending in July and August 1944

	date of arrival.	Initial strength	Cases during weeks ending									
			Jy* 1.	Jy 8.	Jy 15.	Jy 22.	Jy 29.	A* 5.	A 12.	A 19.	A 26.	
864 Avn. Ingr. Bn.	June 13	766	5	17	19	4	6	3	5	4		
307 Airborne Sq.	17	259	1	5	4	4	2	1	1			
308 Bomb Wing Sq. Det.	20	266	1	5	11	15	4	1				
229 Sig. Bn.	21	163	1	9	10	16	5	2	2			
	July											
63 Bomb Sq.	6	210			2	5	26	36	12	4		
64 Bomb Sq.	13	7				3	28	37	16	2	3	

* Jy - July; A - August

Because such survey methods for pre-determination of foci were hardly practical for advance military operations in these primitive areas and since all such areas were potentially mite-infested as discussed above, without possibility of determining foci in advance of delaying survey work, (Fig. 37), the procedure adopted as most practical for protection of troops in later operations in 1945 in the Philippines^{26,41} and Burma,²⁷ was the wearing of repellent treated clothing at least during initial establishment or during periods of exposure in jungle exercises, patrol work and the like.^{56,66,89}

So-called "miticides" were first screened or tested against North American chiggers at the Orlando Laboratory of the Department of Agriculture in cooperation with the Office of Scientific Research and Development, and The Surgeon General's Office of the War Department.

A subcommittee of the OSRD Insect Control Committee with representatives of these and other agencies held their first meeting on 5 April 1945 to discuss problems of scrub typhus control, at which time the most promising of the miticides were considered and further plans for their checking in SWPA were discussed.⁶⁵

Combat and staging activities provided a large proportion of the cases in both theaters under conditions in which the only possibility of protection in the absence of a protective vaccine was the wearing of uniforms protected against mite attacks by these miticidal insect repellents applied either by hand (Fig. 50) or as an emulsified dip. Hand application was used in American forces chiefly as an emergency measure or to fortify protection under certain critical conditions.⁴⁰ Following initial studies which determined the efficacy of impregnated clothing for protection from mite attack at Dobadura^{65,67} by the USA

Typhus Commission (Figs. 5 and 38) the first large-scale field use of this method of protection was by the 31st and 37th Divisions staging in the Oro Bay area in the spring and summer of 1944.^{60,71} The feasibility of wearing such treated clothing under jungle conditions was demonstrated.⁶⁰ It also answered the need for protection of personnel exposed in foxholes, temporary air-raid shelter and fighting through grass. It was therefore possible to recommend this as a supplemental measure of control by mid-July 1944, when the Owi-Biak epidemic started.⁹

"Two members of the Typhus Commission volunteered and were sent to the area to assist and observe the effects of impregnation of clothing with soap suspension of dimethylphthalate. They arrived on 18 July (D + 20) and were helpful in encouraging and demonstrating the method which had been recommended. The process was adopted with enthusiasm by commanders of air and ground forces since the outbreak was large enough to cause serious depletion of troop strength. Evaluation of its effect is not possible in this instance since methods of rodent and mite control were instituted simultaneously."

During this epidemic, demonstrations were made before key personnel of every unit as well as to many units in other staging areas in New Guinea. After initial indoctrination of mite and scrub typhus control practices (Fig. 40), soap emulsions of dimethyl phthalate were prepared, and formations were instructed in clothing impregnation (Figs. 43 to 45). Thereafter most units kept constant supplies of emulsion available. (Fig. 46).

The experience gained up to this time was incorporated in a technical USAFME memorandum entitled "Control of scrub typhus" dated 6 August 1944.⁶⁹

Problems of supply prevented the most effective universal practice of this method, but in reports of the Mansapor^{48,66} and New Bougainville^{5,70}



Figure 42. Indoctrination of troops of 308th Bombardment Wing in mite and disease control prior to demonstration of clothing impregnation with miticide during the Owi Island epidemic.
(USATC Neg., GNM)



Figure 43. Before bulk dimethylphthalate became available, the miticide had to be removed from bottles by this tedious procedure before emulsification.
(USATC Neg., CBP)



Figure 44. Pouring the concentrated diethylphthalate soap emulsion into container during demonstration to Wind Evacuation Hospital personnel of anti-slime clothing treatment. Note GI (kitchen) wire egg-whip used to emulsify repellent-soap mixture. (USMC Neg., CBP)



Figure 45. Formation of 804th Aviation Engineers on Owi Island for immersing clothing in antislime emulsion. Stirring with stick in 50-gallon drum keeps emulsion from settling; immersed clothing is wrung out over GI Can to save excess solution. (USMC Neg., CBP)

epidemics protection was apparently demonstrated for units wearing impregnated clothing as compared to higher incidence of disease of unprotected units under conditions of similar or identical exposure. The intensification of anti-mite measures in a given beachhead as an epidemic progressed is illustrated in successive directives (11th, 19th and 29th August 1944) of the Thirteenth Air Task Force at Sansapor.⁶⁸ Emergency repellent for clothing treatment was flown in for their use and the attack rate among their personnel remained well below that of neighboring ground forces of the 6th Division.⁶⁴

Bulk dimethyl phthalate in gallon containers became available in the Southwest Pacific area in the summer of 1944, and simplified impregnation routines by units. The use of Quartermaster mobile laundry (ML) units (Fig. 47) for bulk clothing treatment on three New Guinea bases was instituted shortly before the initiation of the Philippine campaign.⁷⁵ Personnel and equipment of the Chemical Warfare Service aided both in development of practical procedures⁷⁶ and in emergency bulk anti-mite treatment of uniforms.¹⁷

Most of the Task Force operations during re-occupation of the Philippine Islands were by troops protected in this way. Evaluation of protection afforded was difficult, but the low incidence on Leyte and Mindanao was suggested (though also questioned) as due to this protection.⁴¹ Bulk repellent with emulsifier added to facilitate field impregnation was recommended in December of 1944 but did not arrive in the field in time to be used extensively.⁷²

In January 1945, with the use of some 200 volunteers,⁷³ (Figs. 48 and 49) jungle tests by the USA Typhus Commission near Hollandia proved the superiority of benzyl benzoate and dibutyl phthalate over dimethyl



Figure 46. Vats of emulsion were kept on hand at all times during Owi epidemic for re-treatments of uniforms, like this scene at 60th Construction Battalion installation.
(Navy Photograph)



Figure 47. Chemical Warfare Service M1 plant converted to mass treatment of uniforms with miticide, Hollandia, Dutch New Guinea.
(SC Neg., SWPA 45-6496)



Figure 48. Volunteers from the 20th Replacement Depot, Hollandia, Dutch New Guinea, wearing numbered uniforms impregnated with different miticides during United States Army Typhus Commission tests of improved, laundry-resistant emulsions and undergoing 2-hour jungle exposure to heavy chigger infestation.
(SC Neg., SNPA 45-6415)



Figure 49. Officers volunteering for same jungle exposure.
(SC Neg., SNPA 45-6416)

phthalate both for durability and laundry resistance,⁷⁴ and the former was put into procurement by the Quartermaster, subsequent to its recommendation in March 1945, but the early capitulation of Japan circumvented distribution among staging units.

The surgeons of both the Sixth and Eighth Armies which were staging in the Philippines, had requested in June and July 1945 that stock impregnation of combat issue clothing be considered⁷⁷ but it was later decided⁷⁸ after consultation of representatives of various agencies concerned, to recommend that woolen clothing be not impregnated for wear between October and June which would include the projected "Coronet" operation against Honshu in early December. The Chemical Warfare Service and Quartermaster in Manila had completed plans for request for clothing impregnation if this had been demanded by units going into priority areas in Japan in this final assault.⁷⁹

Clothing impregnation with miticides was never practiced in Burma to the extent that it was in SWA during military operations.⁸³

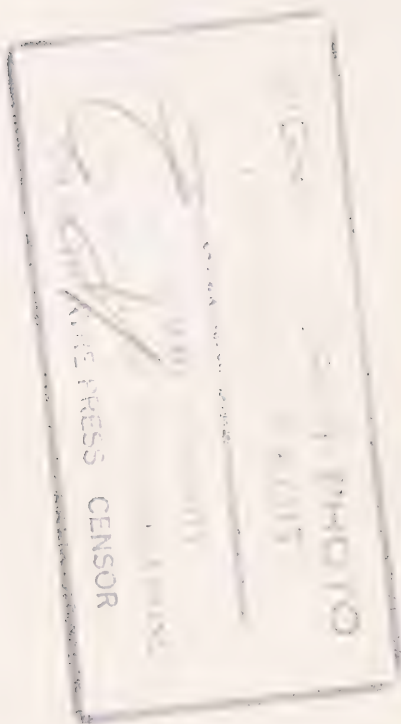
Prevention and control of scrub typhus during combat and staging in connection with the 3 major episodes discussed in this history consisted in the main of preparation of camp-sites to eliminate mites, and of the use of so-called miticides for either hand-treatment (Fig. 50) or impregnation of uniforms (Fig. 45) to protect troops in primitive, uncleared areas.

Certain measures were taken during epidemics which augmented the above practices. During the Owi epidemic, all air force personnel were required to mark a yellow "X" on the backs of treated fatigues to indicate both indoctrination of anti-mite practices, as well as clothing treatment (see poster, Fig. 51).⁸⁴ Some units also required date of impregnation painted on their uniforms.

Figure 50. Contrast of American and Japanese precautionary measures prior to hunt for mite-bearing rodents in Niigata, Japan (see Fig. 28). Hand-applied dimethyl phthalate is used by these 2 officers, the Japanese puts on a one-piece suit with wrap leggings and canvas (split-toed) shoes. (SC Neg. 216296).

216296





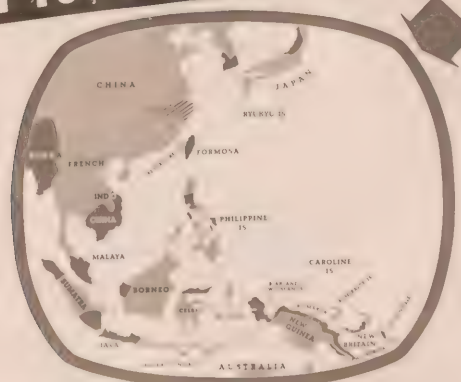
52



Figure 51. Poster used in SNPA to combat scrub typhus.
(M & MAS Neg., 78106)

Figure 52. Posters developed in Office of The Surgeon General for field distribution to control scrub typhus (M & MAS Neg. 98,188).

IF YOU ARE IN THIS AREA



LOOK OUT FOR
Scrub Typhus
FEVER

DO THIS

Choose ground as dry as possible for your camp site

Clear and burn over area

Avoid contact with rubber trees and decaying vegetation

Wash unimpregnated clothing when directed

Wear Clothing that has been *IMPREGNATED* ...



IMPREGNATED clothing offers protection from
Scrub Typhus
FEVER

IMPREGNATION
gives protection from

Scrub Typhus Fever

Be sure your clothing is properly impregnated

DO IT THIS WAY

1. Dip clothing in impregnating solution

2 2. Dry clothing thoroughly before wearing

3 3. Wear only impregnated cloth

Maybe you had chiggers back home but none like these

This chigger is a common vector for scrub typhus. It is a small, reddish-brown insect, about 1/4 inch long, with 4 pairs of legs. It is found in the grass and brush of a forest.



THIS CHIGGER CARRIES

Scrub Typhus
FEVER

DO THIS

1. Dip clothing in impregnating solution

2. Dry clothing thoroughly before wearing

3. Wear only impregnated cloth

4. Wash unimpregnated clothing when directed

Oags and squibbs were prepared for local, daily news sheets of various units to stimulate anti-mite consciousness among the men of the respective units.⁸⁰ Posters were also prepared to impress the need for caution in regard to the disease (Figs. 51 and 52). Directives were issued when needed restricting certain activities, correcting wearing apparel, and placing dangerous areas "off limits" as indicated by the local emergency.⁸¹

IX SUMMARY

1. The total number of cases of scrub typhus in American Army Forces in all areas from March 1942 through December 1945 was 6,717, as reported by the Statistical Health Reports in The Surgeon General's Office. Presentation of such statistical data necessarily precede discussion of the epidemiological and focal features of the disease in the Army experience.

2. Cases were distributed by theaters of operation as follows: Southwest Pacific - 5,718, South Pacific - 32, and China-Burma-India - 967. Omitting from consideration the small number of South Pacific area cases, the respective hospital admission rates per 1,000 per year were: SWPA, 3.34 and CBI, 2.23.

3. Epidemiological data pertaining to these are discussed as three major Army episodes geographically: (1) New Guinea and adjacent areas, (2) the Philippine Islands, and (3) the CBI where the bulk of the incidence was in north Burma. Scrub typhus was of only incidental military importance during re-occupation of the Philippine Islands, and there was only negligible incidence in the South Pacific area, northern Queensland, Australia, and Assam, India.

4. Documentary confirmation of origination of reported cases in China is almost totally lacking. One serologically confirmed non-fatal army case was apparently infected near Kunming.

5. The few cases in the South Pacific forces were contracted on Bougainville, New Georgia, and Espiritu Santo. Three proven cases on the latter island constituted the farthest east the disease was encountered.

6. No cases developed during the noncombat occupation of the endemic areas in northwestern Honshu, Japan, in the fall of 1945.

7. Epidemics starting immediately following the landings on the Owi-Biak Islands and at the Sansapor beachhead in Dutch New Guinea developed into the two most serious episodes experienced. In five months, 1469 cases were hospitalized during the Owi-Biak epidemic, and at Sansapor 931 cases in 53 days. The First Infantry Regiment of the 6th Division was rendered almost completely noneffective militarily within a month of landing at Sansapor.

8. Judged by mortality rates, virulence varied in different areas, but the greatest extremes were encountered in local epidemics in New Guinea, namely, 0.06% at Owi-Biak to 35.3% at Finschhaven. The average mortality rate in the three major episodes was between 5 and 10%.

9. A large proportion of cases in all areas was contracted during combat or staging maneuvers in primitive environments. Peaks of incidence were related to such military activities rather than to seasonal influences.

10. No one ecological type was identifiable as a typical scrub typhus focus, and the variation in environments in contributing to the infection of troops as the campaign progressed indicated the impossibility of predicting focal areas ahead of occupation. Foci was encountered in fields of native grass, neglected coconut plantations, abandoned native

villages, vine-grass margins of tropical rain forest, and at least in Burma even in primary jungle.

11. Army agencies contributed fundamental epidemiological information of the disease incidental to the primary medical and preventive functions of the medical department.

a. Transmission of the disease through the agency of larval, trombiculid mites or chiggers was abundantly confirmed in the laboratory as well as circumstantially. No evidence was obtained of other kinds of "insects," such as ticks, acting as vectors.

b. Two vector species of mites were incriminated circumstantially in several foci, namely, Trombicula deliensis (synonym walchi) and T. akamushi (synonym fletcheri). Each was confirmed by animal experimentation in Army field laboratories in New Guinea and in Burma where 5 and 53 strains respectively were recovered from naturally infected mites. Hyperendemic areas in Burma were shown to have a correlation between high incidence following exposure and a high percentage of T. deliensis in mite samples on indigenous rats.

c. Transevarial (generation to generation) transmission of the disease agent was confirmed in laboratory reared mites in the Burma studies.

d. Strains of infection were also obtained from indigenous species of rats in both New Guinea and Burma, and from Assamese tree shrews.

e. The identity of the strains of disease encountered during the three major episodes with one another and with classical Japanese tsutsugamushi disease was confirmed serologically and by animal experimentation.

12. Control measures adopted during military operations in the absence of an available protective vaccine were of two sorts, (a) personal protection and mite avoidance, and (b) mite reduction by environmental manipulation or intensive clearing of camp-sites. Early in the campaign clearing, burning and camp sanitation were the methods chiefly relied upon to reduce hazards where foci were encountered, but this did not always prevent the continuation of cases. A method of clothing treatment with a 5 per cent emulsion of insect repellent was developed by the USA Typhus Commission team in New Guinea which was widely used beginning in 1945 in endemic areas for protection of both combat and staging troops.

13. The Army experience with scrub typhus was unfortunate with many thousands of man-days lost, but it never proved strategically critical. Under the impetus of military pressure, knowledge of the disease and its geographic distribution in the Pacific-Asiatic region was vastly expanded and techniques of protection and control were developed which will be of profound benefit not only in the further postwar development of the endemic areas but also in protection against chigger attacks in other parts of the world.

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II. APPENDIX A

SCRUB TYPHUS IN THE JAPANESE FORCES

A complete chronicle of information on scrub typhus in the Japanese combat forces does not belong in this history, but it is not out of place to call attention to a considerable Army documentation which accumulated in both SWPA and CBI theaters from various sources of interrogation of prisoners, translations of captured medical reports, and intelligence reports. No attempt has been made here to give more than a few examples which will serve to provide some idea of geographic distribution of Japanese cases.

The lack of any racial difference in susceptibility to scrub typhus between Orientals and Caucasians was apparent in the preceding account of the Burma experience.²⁷ It was learned that the disease also was experienced by the Japanese forces in northern Burma, where it was sometimes referred to as "Burma eruptive fever," or given a place name as "Tantha disease". The infection is sometimes described with typhoid-like symptoms, with negative Widal's, sometimes likened clinically to "mite-borne typhus fever" with strong CXK agglutination and other symptomatic similarities. Specific Burma locations mentioned include: Upper Chindwin, vicinities of Mandalay, Sagaing and Amarapura, Wundwin and other villages within 100 miles of Mandalay.⁸⁴ Mortality rates were low (one specific figure 7.4%), but "numbers of men" passing through the Boma Hills east of Kohima became infected, "most of the patients contracting the fever died after about 14 days."⁸⁴ There is record of a special field study which included injection of laboratory

animals and reported recovery of Rickettsiae from "Nanking mice" infected with patients' blood.⁸⁵

Captured enemy documents have indicated that hospitalizations of toutsugamushi-like fevers had occurred during Japanese operations both in New Guinea and in the southern Philippines. The laboratory sections of certain of their hospitals and water purification units were probably equipped to do Weil-Felix tests.^{25,86} While their medical reports called attention to the similarity of cases in certain areas to toutsugamushi or flood fever of Honshu, often with positive OXA serology, they appeared reluctant to so name the disease encountered in southern combat areas. Instead, we find reference to such names as "Hansa Bay" and "Kewak" fevers.⁸⁶ It is difficult to believe that when driven into the coralline ridges of Biak and bivouacked in Sansapor Village they would have missed encountering the disease but captured prisoners with medical background were not plentiful for questioning in this regard.⁸⁶

Captured documents⁸⁶ indicate cases were encountered by the Japanese in western New Britain, and a medical report gives data on 65 cases in their First Field Hospital at Madang with 2 deaths. Positive OXA titers of 800 or better were observed in 22 instances.

While there was only one recorded case in the U. S. Forces on Mindanao of the Philippines, an AFIP report indicates there were cases among Japanese troops in an unspecified area on that island.^{25,26} Again the disease was only likened to toutsugamushi disease, but not diagnosed as such in spite of positive Weil-Felix and presence of rash and adenopathy.

XII. APPENDIX B

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By ARMY PERSONNEL

on

TSUTSUGAMUSHI DISEASE
(Scrub Typhus)

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General

Medical and Epidemiological

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GENERAL

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